July/August, 1973
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Ursula Marvin on "The Moon After Apollo": Our new knowledge of lunar history represents "a revolutionary advance in planetary science."

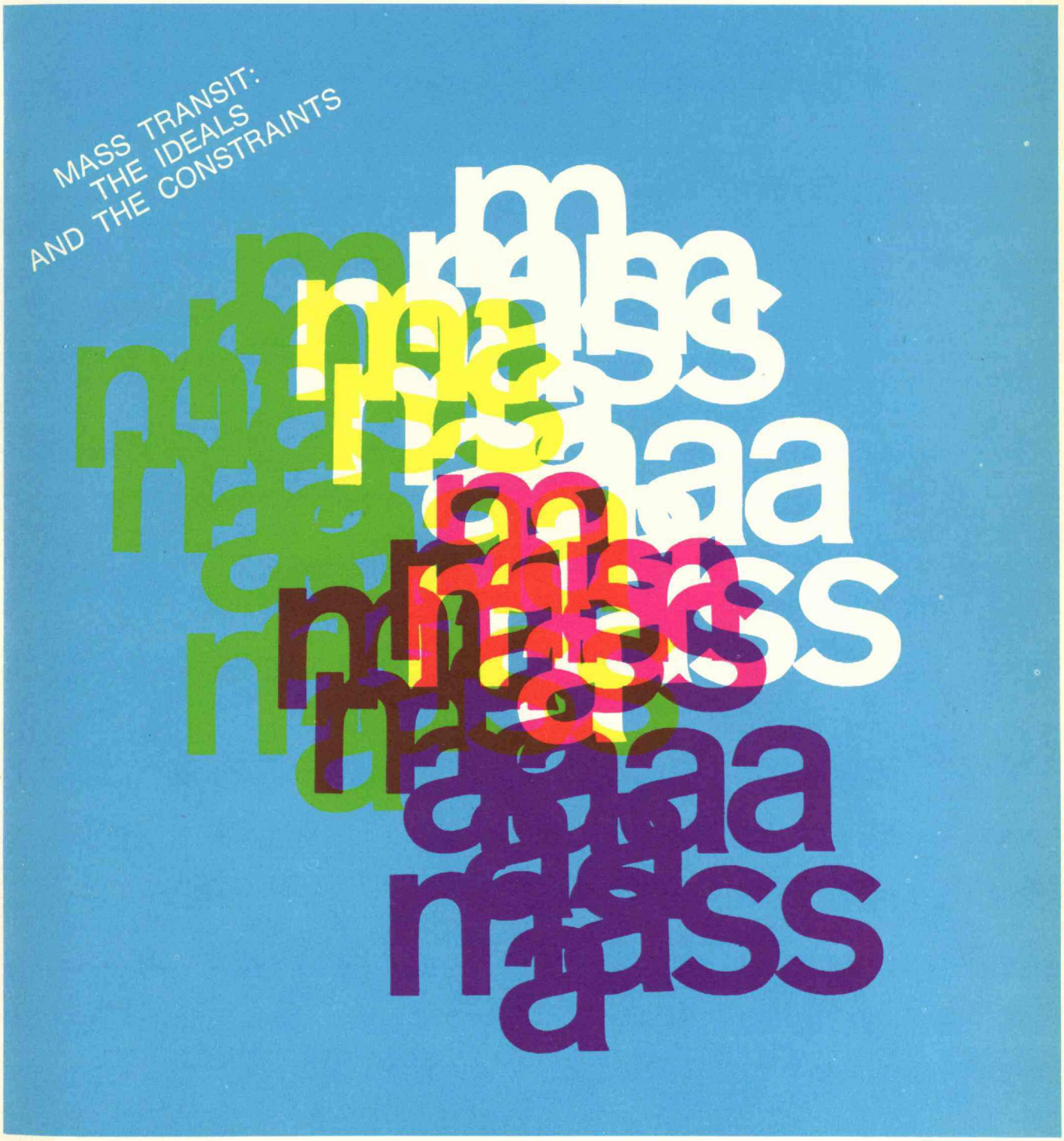
Amar G. Bose on "Sound Recording and Reproduction II": If a distortionless array displayed apparent distortions, what other parameters remain to control?

Stuart E. Madnick on "The Future of the Computer": Computer systems have captured public attention and yielded basic changes in American life. Their future course will depend as much on the way we use information as on the technology we apply to it.

Edited at the Massachusetts Institute of Technology

Technology Review

MASS TRANSIT:
THE IDEALS
AND THE CONSTRAINTS



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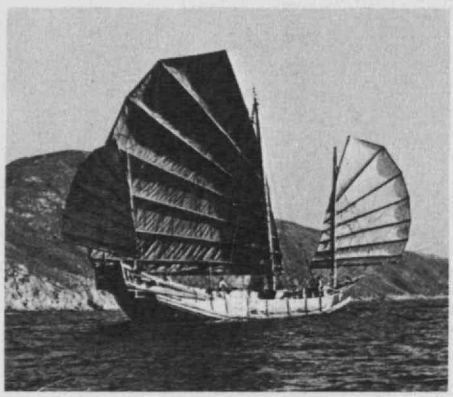

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AEGEAN ADVENTURE

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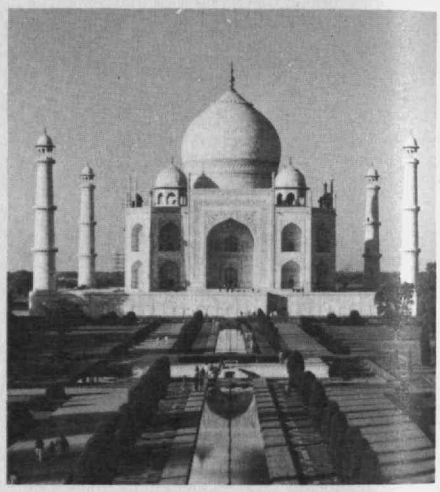
This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean, and Asia Minor—not only the major cities but also the less accessible sites of ancient cities which have figured so prominently in the history of western civilization, complemented by a cruise to the beautiful islands of the Aegean Sea. Rarely has such an exciting collection of names and places been assembled in a single itinerary—the classical city of ATHENS; the Byzantine and Ottoman splendor of ISTANBUL; the site of the oracle at DELPHI; the sanctuary and stadium at OLYMPIA, where the Olympic Games were first begun; the palace of Agamemnon at MYCENAE; the ruins of ancient TROY; the citadel of PERGAMUM; the marble city of EPHESUS; the ruins of SARDIS in Lydia, where the royal mint of the wealthy Croesus has recently been unearthed; as well as CORINTH, EPIDAUROS, IZMIR (Smyrna) the BOSPORUS and DARDANELLES. The cruise through the beautiful waters of the Aegean will visit such famous islands as CRETE with the Palace of Knossos; RHODES, noted for its great Crusader castles; the windmills of picturesque MYKONOS; the sacred island of DELOS; and the charming islands of PATMOS and SANTORINI. Total cost is $1429 from New York. Departures in April, May, July, August, September and October 1973.

SOUTH AMERICA

32 DAYS $1995

From the towering peaks of the Andes to the vast interior reaches of the Amazon jungle, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America: a brilliant collection of pre-Colombian gold and a vast underground cathedral carved out of a centuries-old salt mine in BOGOTA; magnificent 16th century churches and quaint Spanish colonial buildings in QUITO, with a drive past the snow-capped peaks of "Volcano Alley" to visit an Indian market; the great viceregal city of LIMA, founded by Pizarro, where one can still see Pizarro's mummy and visit the dread Court of the Inquisition; the ancient city of CUZCO, high in the Andes, with an excursion to the fabulous "lost city" of MACHU PICCHU; cosmopolitan BUENOS AIRES, with its wide streets and parks and its colorful waterfront district along the River Plate; the beautiful Argentine LAKE DISTRICT in the lower reaches of the Andes; the spectacular IGUASSU FALLS, on the mighty Parana River; the sun-drenched beaches, unforgettable mountains and magnificent harbor of RIO DE JANEIRO (considered by many the most beautiful city in the world); the ultra-modern new city of BRASILIA; and the fascination of the vast Amazon jungle, a thousand miles up river at MANAUS. Total cost is $1995 from Miami, $2080 from New York, with special rates from other cities. Optional pre and post tour visits to Panama and Venezuela are available at no additional air fare. Departures in January, February, April, May, July, September, October and November 1973.



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An unusual opportunity to view the outstanding attractions of India and the splendors of ancient Persia, together with the once-forbidden mountain kingdom of Nepal. Here is truly an exciting adventure: India's ancient monuments in DELHI; the fabled beauty of KASHMIR amid the snow-clad Himalayas; the holy city of BANARAS on the sacred River Ganges; the exotic temples of KHAJURAHO; renowned AGRA, with the Taj Mahal and other celebrated monuments of the Moghul period such as the Agra Fort and the fabulous deserted city of Fatehpur Sikri; the walled "pink city" of JAIPUR, with an elephant ride at the Amber Fort; the unique and beautiful "lake city" of UDAIPUR; and a thrilling flight into the Himalayas to KATHMANDU, capital of NEPAL, where ancient palaces and temples abound in a land still relatively untouched by modern civilization. In PERSIA (Iran), the visit will include the great 5th century B.C. capital of Darius and Xerxes at PERSEPOLIS; the fabled Persian Renaissance city of ISFAHAN, with its palaces, gardens, bazaar and famous tiled mosques; and the modern capital of TEHERAN. Outstanding accommodations include hotels that once were palaces of Maharajas. Total cost is $1825 from New York. Departures in January, February, August, September, October and November 1973.

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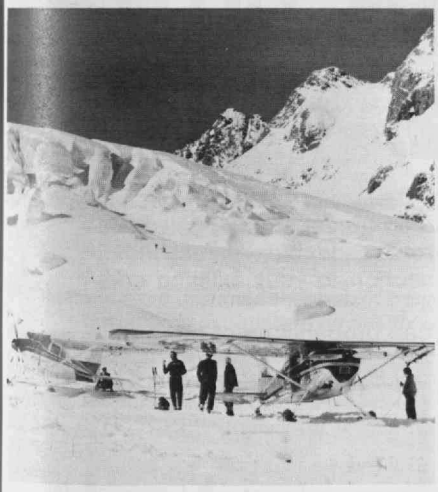

EAST AFRICA

22 DAYS $1739

A luxury "safari" to the great national parks and game reserves of East Africa, offering a breathtaking combination of wildlife and scenery: game viewing in the wilderness of Kenya's Northern Frontier district at SAMBURU RESERVE; a night at world-famous TREETOPS in the ABERDARE NATIONAL PARK; the spectacular masses of pink flamingos at LAKE NAKURU; multitudes of lion, zebra, wildebeest and other plains game in the MASAI-MARA RESERVE and the famed SERENGETI PLAINS; the great permanent concentrations of wildlife in the NGORONGORO CRATER; tree-climbing lions along the shores of LAKE MANYARA in the Rift Valley; photographing rhino and other big game against the majestic snow-covered background of Mt. Kilimanjaro in the AMBOSELI RESERVE; and the vast and fascinating wilderness of TSAVO NATIONAL PARK, renowned for its elephant and lion and for the unusual desert phenomenon of the Mzima Springs. There is also a stay in NAIROBI, the most fascinating city in East Africa, as well as features such as a visit to a MASAI MANYATTA to see tribal dancing and the tribal way of life. The altitude in East Africa provides an unusually stimulating climate, with bright days and crisp evenings (frequently around a log fire), and the tour follows a realistic pace which ensures a full appreciation of the attractions visited. Total cost is $1739 from New York. Optional extensions are available to the VICTORIA FALLS, on the mighty Zambezi River between Zambia and Rhodesia, to UGANDA, and to the historic attractions of ETHIOPIA. Departures in January, February, March, May, June, July, August, September, October, November and December 1973 ($26 additional for departures in June, July and August).

NORTH AFRICAN ADVENTURE

Preliminary Announcement

A new tour to North Africa and the regions which surround it, visiting GIBRALTAR, MOROCCO and the CANARY ISLANDS. GIBRALTAR, the gateway to North Africa, is the first stop, followed by a crossing of the narrow Strait of Gibraltar to TANGIER, on Morocco's northern coast. From Tangier, the tour proceeds by road to the imperial cities of MEKNES and FES, with an excursion to the Roman ruins of VOLUBILIS, then crosses the Atlas Mountains to the pre-Sahara and ERFOUD, on the edge of the desert. From here, the famed "casbah trail" leads through TINERHIR and OUARZAZATE to MARRAKECH, where an extended stay is provided before continuing to CASABLANCA. The visit to the CANARY ISLANDS, lying off the coast of Africa, will include stops in TENERIFE, the volcanic island of LANZEROTE, and LAS PALMAS. It is anticipated that the tour will be of three weeks' duration and that it will be inaugurated in the fall of 1973. Further details, including the tour cost, will be announced as soon as possible.

MEDITERRANEAN ODYSSEY

Preliminary Announcement

An unusual blend of countries in the Mediterranean area, visiting TUNISIA, the Dalmatian Coast of YUGOSLAVIA, and MALTA. Starting in TUNIS, the tour explores the coast and interior of Tunisia: the ruins of the famed ancient city of CARTHAGE as well as the ruins of extensive Roman cities such as DOUGGA, SBEITLA, THUBURBO MAJUS and the magnificent amphitheater of EL DJEM, historic Arab towns and cities such as NABEUL, HAMMAMET, SOUSSE and KAIROUAN, the caves of the troglodytes at MATMATA, beautiful beaches at ZARZIS and on the "Isle of the Lotus Eaters" at DJERBA, and desert oases at GABES, TOZEUR and NEFTA. The beautiful Dalmatian Coast of Yugoslavia is represented by SPLIT, with its famous Palace of Diocletian, and the medieval walled city of DUBROVNIK, followed by the island of MALTA, with its treasure house of 17th and 18th century churches and palaces, where the Knights of St. John, driven from the Holy Land and from Rhodes, withstood the epic seige of the Turks and helped to decide the fate of Europe. It is anticipated that the tour will be of three weeks' duration and that it will be inaugurated in the fall of 1973. Further details, including the tour cost, will be announced as soon as possible.

* * *

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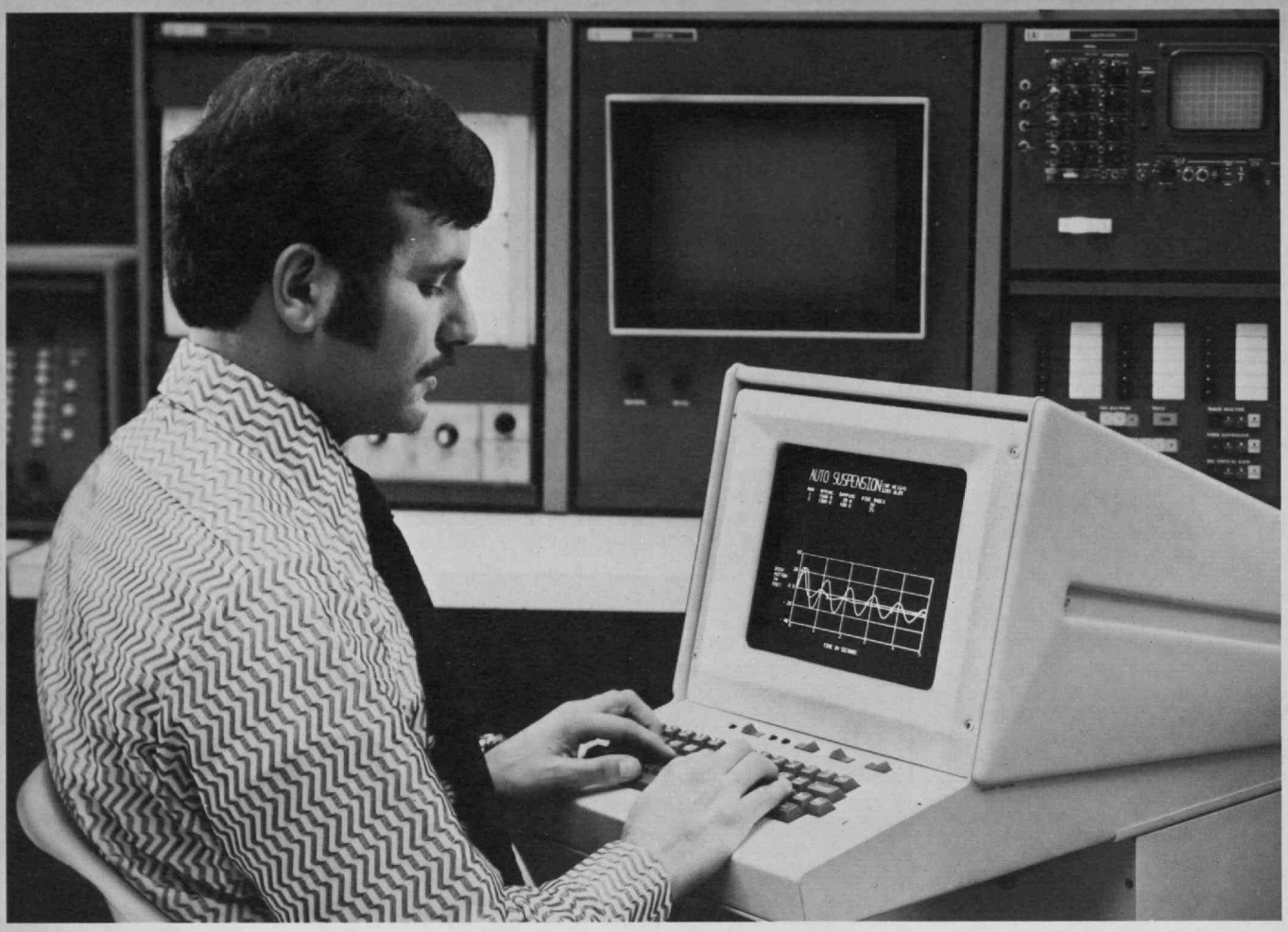

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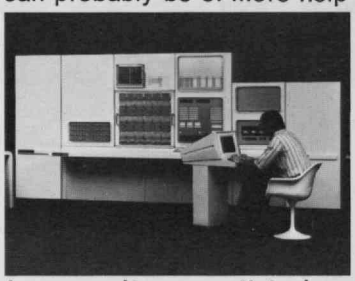

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Technology Review

Edited at the
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Volume 75, Number 8
July/August, 1973

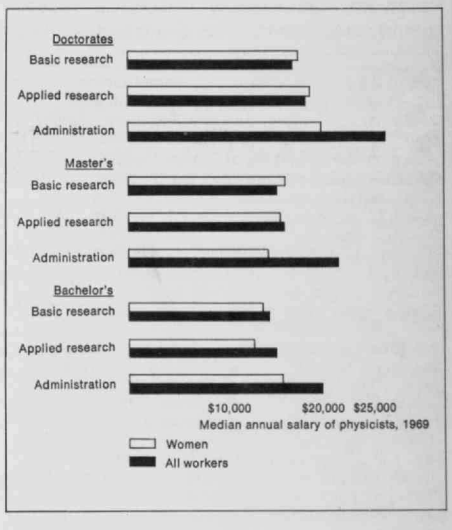
Articles

Departments

The First Line

The Women Wronged

Only a few hours were needed for the *Review* to stand corrected on a sensitive—and important—point on which no editor would have chosen to be in error. A chart on page 56 of *Technology Review* for June proposed to show that women physicists working in government laboratories are paid less, almost without exception, than the average of all physicists of equivalent qualifications in government laboratories. The chart, with the legend corrected (the designations were originally reversed), is reproduced below.



Volume 75

This issue completes Volume 75 of *Technology Review*. An index is in preparation and will upon completion be sent without cost to all subscribing libraries; others requiring the index may write to place their names on the list to receive it.

As we complete the volume, we announce with regret that Janet Kreiling, Associate Editor of the *Review*, has resigned to take an important assignment in educational television. She has brought wisdom, perception, and a woman's touch to the magazine since September 1969; and readers who are unaware of the implications of that statement will soon enough discover as the *Review* appears in the future without benefit of Miss Kreiling's special talents.—J.M.

Letters

The "Fusfeld Functions"

Concerning the dialogue on the use of mathematical symbols in *Technology Review (see "The First Line," February, p. 3)*, I find that I am of a mind with Michael Faraday. In a letter to the theoretician James Clerk-Maxwell, Faraday, the experimentalist, made the following request (The New Yorker, *March 10, 1973, p. 56*):

"When a mathematician engaged in investigating physical actions and results has arrived at his conclusions, may they not be expressed in common language as fully, clearly, and definitely as in mathematical formulae? If so, would it not be a great boon to such as I to express them so?—translating them out of their hieroglyphics, that we might also work upon them by experiment. I think it must be so, because I have always found that you could convey to me a perfectly clear idea of your conclusions, which, though they may give me no full understanding of the steps of your process, give me the results . . . and so clear in character that I can think and work from them."

Ralph Segman
Cambridge, Mass.

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An Unstressed Reader

The Editor's concern that many readers may not be willing to cope with the intellectual exercises presented by the mathematical functions in Alan R. Fusfeld's article ("The Technological Progress Function," *February, pp. 29-38*) is unfounded from my point of view. Mathematical/intellectual exercises have always been a part, though optional to the reader, of *Technology Review*—to wit, "Puzzle Corner" by Allan Gottlieb. More importantly, the level at which Mr. Fusfeld presented the mathematical material and the ample written explanations supporting those expressions leave the reader relatively unstressed.

As long as equations are described in literal form and well supported by graphics, the future inclusion of similar articles will greatly enhance the value of *Technology Review* to me.

G. M. Kipnis
New York, N.Y.

Productivity and Progress

Two further comments about technological progress functions, stimulated by Alan Fusfeld's fine article (*"The Technological Progress Function," February, pp. 29-38*):

First, Fusfeld states that "the two versions (i.e., technological progress as a function of time and the Fusfeld cumulative experience forecast) agree if and only if the rate of production is a constant fraction of total production to date. And that is experiential growth." This is not quite correct. One can easily convince one's self that the two are, in general, equivalent when b (the "experience" constant) is equal to 1; and, in any case only differ as the inverse power of b. This is important because it implies that the reason that so little difference is apparent in Fusfeld's curves and those of the conventional time series forecasts is that, by and large, the same functional relationships exist in each formulation. This in no way diminishes the importance of Fusfeld's contribution. He has certainly provided us with greater insight into the process of technological progress and this is important. The fact that a learning curve formulation correlates the data provides a rational for action that this simple time series can not.

Secondly, it is interesting to note that Mansfield and others have shown that productivity has the same type of "experience" curve relationship to cumulative research and development expenditures within an industry. This observation has interesting implications for research and development policy. One can easily show that the key variable for policy is the relationship of the "experience" exponent (b) to the exponent which expresses the growth of research and development expenditures with time. Generally, if both are positive, that is research and development expenditures are increasing as a function of time and productivity is improving as a function of research expenditures, then productivity will increase over time. However, if research and development expenditures increase at a low rate (say as the square root of time) and productivity is less than fully responsive to the increasing stock of research and development (as it is non-durable goods where $b=0.1$) then one can actually find one's self with a declining rate of productivity increase. This is precisely what has been happening over the past few years in the U.S. To the extent that we fail to increase our rate of expenditures on research and development or continue to fail to understand how better to utilize the results of research and development to increase productivity, particularly in sectors of increasing importance—non-durable goods and services—we can expect to see little progress in productivity and therefore inflation and thus international competitiveness.

Richard N. Foster
Cambridge, Mass.

The writer is Director of the Technology Management Group of Abt Associates, Inc.—Ed.

Mr. Fusfeld comments:

Mr. Foster's comments are particularly insightful. Their focus involves the functional forms of three relationships:

☐ Technology as a function of cumulative production (the technological progress function), $T = h(i)$.

☐ Technology as a function of time (the technology time trend), $T = f(t)$.

☐ Cumulative production as a function of time, $i = g(t)$.

When any two of the three relationships are assumed fixed in form, it is possible to derive specific characteristics of the third. Dr. Foster and I differ in our selection of which functions are assumed to be fixed in form.

Cellular Regeneration

Though Dr. Robert O. Becker's hypothesis regarding the role of piezoelectrically-generated currents in remolding stressed osseous tissue is intriguing (*"Electromagnetic Forces and Life Processes," December, pp. 32-38*), his model of externally applied electric fields in causing cellular dedifferentiation of the red blood and hence regeneration appears untenable to me.

His model system describes the dedifferentiation of the red blood cells into an imitative cell. This cell is then to differentiate despite the combined presence of the external field into an entirely different mature species such as cartilage or bone. I would be interested in knowing how Dr. Becker proposes an enucleate cell such as the mature red blood cell could possibly reacquire its lost genetic material and then "dedifferentiate."

Stephen E. Straus, M.D.
Richmond Heights, Mo.

Dr. Becker responds:

I fear Dr. Straus missed the point mentioned in the legend for the illustration on page 36: ". . . in all vertebrates other than mammals . . ." I'm sure that he is aware that only the mammals have enucleate red cells; all other vertebrates have erythrocytes with nuclei that are fully competent, genetically speaking. Of course, no one can effect any such D.N.A.-determined transformations on the mammalian red cell.

It might not be amiss to comment that the mechanism described is a very useful one for organism survival: if the red cells in the blood clot at any injury site had the capacity to dedifferentiate and then redifferentiate with the cell type required, healing would be considerably expedited. We apparently have "traded off" this ability for increased oxygen transfer capabilities.

Hard Work, Small Reward

The lag in the supply of new engineers (see "Engineering: Prosperity Returns?" in "Trend of Affairs" for March/April, p. 73) is not due to waiting "for the message of manpower needs" to filter to students and their parents.

First, part of the manpower needs for new graduates is obviously to fill the jobs of older engineers whose yearly salary increases have compounded them out of a job. It would be comforting to say they were all "overspecialized" or "technically obsolete," but it is simply not true.

Secondly, it is a bit fanciful to link the words "prosperity" and "engineering" in the same sentence. The good vacations, the fine cars and houses in the nicer part of town are left to other professions. Raises, geographical location, and continuity of employment are usually at the whim of some larger institution.

My point is that young people can see these things for themselves, and if they can't, engineers will tell them (most people know at least one engineer). The message is simple: it's a tough, demanding course of study for very limited reward.

Milton I. Lilie
Stamford, Conn.

Can Marketing Aggregate the Environment Market?

Terry Rothermel's description of "The Profit Side of Pollution Control" (*January, pp. 49-56*) is a capable and usefully skeptical analysis, one which should be helpful to those contemplating investment in the pollution control industry. It is worth noting, moreover, that the tone of the article, to the degree that it is representative, confirms Natural Resources Counselor Earl Butz' contention that we have passed "the crest . . . of the environmental binge we're on." While we should doubtless be pleased that "we have markedly departed from the simplistic positions of environmental prophets," (*p. 49*) it is perhaps not out of place to remark that "the proper blend of technology and marketing" (*p. 56*) is closer to the narrow letter than the broad spirit of Earth Day.

For there can be little doubt that the environmental concerns of the last several years have included the feeling that the despoliation of our natural surroundings is more than *merely* a blemish to be excised by the most efficient technical means. As Langdon Winner noted recently, we feel the need to do more than set the standards of acceptability: "The point of the matter seems to be that the standards themselves must be open to question. . . . Our beliefs concerning the inherent beneficence of economic and

(Letters continued on p. 80)

Watergate Bug Infects Technology

Washington Report
Victor Cohn

It is the time of the Watergate, and the spirit of the Water-bug in Larry O'Brien's telephone has infested all aspects of American life, including science and technology.

For at least the past 28 years, since Hiroshima, thoughtful citizens have warned of two dangers: the subversion of government by science and technology and the subversion of science and technology by government. The events of recent months, the revelations of the Watergate and all that has gone with it, tell us that both are happening—sufficiently, at least, to give us future warning; and possibly even more seriously, to imperil us now.

For all these revelations are shot through with the nastiest applications of some of our proudest sciences and cleverest technologies. The surveillance at the Watergate, the bugging and attempted bugging interrupted by arrests on the night of June 17, 1972—this was not just old-fashioned gumshoe surveillance but electronic surveillance. Another electronic device, the walkie-talkie, had been intended to prevent the arrests, and would have done so but for an unpredictable fluke.

A radio-equipped E. Howard Hunt was stationed in Room 419 of the Howard Johnson Motel on that night to watch the Watergate apartment and office complex and warn of any police. When an $80-a-week security guard spotted some adhesive tape over a door-lock, removed it, returned later, found more tape, and alerted the police, the nearest squad car in the vicinity of Virginia and New Hampshire Avenues NW just happened to be an unmarked car manned by three plainclothes police.

They thus escaped Hunt's attention and radio-equipped electronic agent James McCord went unwarned; otherwise we would probably be ignorant still of not only this event but also the whole White House and White House-directed spying and sabotage apparatus that it represented.

U.S. political parties have often tried to plant operatives in the enemy camp to report inside plans, but none had ever been inside a campaign manager's telephone before, so far as we know. The difference, considering only technology, is like the difference between the longbow and atomic bomb, to repeat a Hiroshima-era analogy. Consider now the imminent if not current advent of eavesdropping by the super-sensitive long-distance parabolic listening device aimed like a rifle, or eavesdropping by bouncing a laser beam off a window to pick up conversations by their vibrations, and the difference becomes the difference between the A-bomb and H-bomb.

Add the fact of a White House security apparatus a la James Bond, dispatching its own agents, co-opting the aid of the F.B.I. and C.I.A., and you indeed bear out the warnings about *1984*'s Big Brother invading our lives. All in all, noted *Time* magazine, agents like G. Gordon Liddy and Hunt "set out with zest, technological skill and a mind-boggling indifference to the Bill of Rights."

Stretching the Boundaries

All this, we learned, started in 1969, shortly after President Richard M. Nixon took office, when what was later dubbed a White House "plumbers' squad" was first mobilized to seek out leaks of facts to the press and make some wiretaps on over-inquisitive newsmen and National Security Council officials suspected of being over-candid. What was that super-secret information that the administration in the spring of 1969 was so zealously guarding, causing it to give birth to this new presidential black squad that was later to be assigned to help re-elect the President?

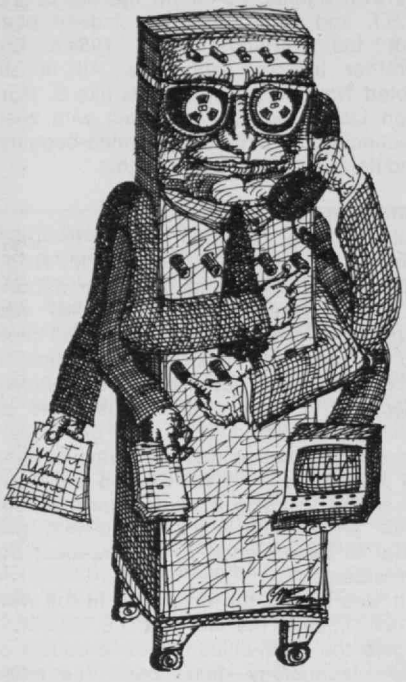
It was in part the revelation in the *New York Times* of the fact that U.S. aircraft—again the multi-million-dollar products of our technology—had been pounding Cambodia with the acquiescence of Prince Norodom Sihanouk. In other words, our leaders were once again extending the boundaries of a war never declared by the Congress, and once again (in the spirit of Lyndon Johnson) using super-secrecy stamps to keep us from knowing or debating it.

Enter a Daniel Ellsberg with the conviction that the public should see at least some of the Pentagon's papers. He too employed a new technological tool indispensable to his peculiar kind of revelation: xerography. He did not "steal" the papers, so it might be maintained, he only copied them—and the legal difference still has not been resolved thanks to his mistrial caused by the government's further use of secret wiretaps, as well as highly sophisticated burglary on Mr. Ellsberg.

Enter a medical science to be subverted. A key to understanding Ellsberg—and thereby convicting him and blocking future pilferers, so it was decided—was to be a "psychiatric profile" such as those the C.I.A. regularly makes of foreign leaders. The C.I.A. ordered its director of medical services and chief of psychiatry to produce such a profile, and they did so, despite—so they have testified—their reservations; for this was to be the first C.I.A. psychiatric profile of a U.S. citizen.

To get input for the profile—or so it was hoped; it is still not clear at this writing whether or not this next caper produced fruitful results—the C.I.A. in the summer of 1971 provided the White House's secret squad with disguises, electronic gear, and cameras to help them burgle Ellsberg's psychiatrist's inner sanctum. In grand jury testimony, Hunt later referred to this as the "bag job on the psychiatrist's office," a tragicomic phrase worthy of only a Hunt or Art Buchwald.

Only a few weeks after we learned about this operation, we learned that Sen. Thomas Eagleton's medical record,



from the Newsletter of Computer People for Peace

"A future bag-job artist equipped with who-knows-what electronic tools."

telling of his 1960, 1964 and 1966 shock therapy, had been burgled too. There have been some suggestions that this job was originally pulled by the F.B.I. as part of the late J. Edgar Hoover's running file on American political officials. In any case, these records had finally reached the White House safe of John Ehrlichman, from whence they found their way into the 1972 headlines that sank Eagleton and damaged McGovern.

Let Congress Act

The everyday applications of this vast rat's nest of technological villainy are only too obvious. Health insurance companies, just to take one example, are already putting medical information on *all* their policy-holders into computer memory banks and exchanging such information through a central repository. How long before all our medical histories will be computerized, with access to anyone with the right code, no matter what "safeguards" are supposedly established? Safeguards might or might not keep the information on my bleeding bonkus from an ordinary prospective employer. They would surely be less effective against a future bag-job artist equipped with who-knows-what electronic tools, or maybe just payoff money and the Watergate-like indifference to the Bill of Rights that we know already pervades far too much of government and society.

One could go on to cite disclosures that collections of political and personal information on thousands of citizens have already been gathered by Army domestic intelligence agents, Congressional internal security committees and—increasingly—state and city police departments. The last group, many of them newly furnished federal Law Enforcement Assistance Administration funds for computers in which to store this data, could potentially interface it with the F.B.I.'s National Crime Information Center. Persons close to this field think it would take a strict act of Congress, one not yet even being debated, to keep this from ultimately happening.

If this did happen, or if it has, we might not even know it. Ellsberg testified that government secrecy has already become so pervasive that there are now some 20 classifications "above top secret" (he himself, he said, possessed 12), though none is authorized by law and all have been set by mere executive regulation. This all amounts, Ellsberg claimed, to "a government of espionage cells" where there could "even be clearances the President doesn't know about" in a system that makes it "your duty to lie" when asked about such information.

On Daniel Ellsberg's say-so, this is not hard enough evidence. But at the least, the many-headed Watergate monster—once all its faces become clearer—should trigger an investigation not just of political espionage and dirty tricks, but of the whole, larger complex of federal secrecy and invasion of Americans' privacy.

This at the least. At the most we had better all ponder the accelerating trend toward impersonal and technologically-equipped government that growing world populations and speeded-up science seem to make inevitable.

Is there any antidote? There is none that is simple. Yet we might try one by one to create what humanistic psychologist Carl Rogers, asking the same question, recently called "a new value system" in which society's "new and powerful person"—small in number, perhaps, yet the change agent—could be each man or woman who shuns Watergate morality and is willing to think through and live by a better set of convictions.

Formerly Science Editor of the Washington Post, *Voctor Cohn now concentrates on major science-oriented reporting assignments for that newspaper.*

Nuclear Relief for Natural Gas?

Peter Gwynne

In mid-May, at the time that engineers of the National Aeronautics and Space Administration were desperately trying to redesign the faltering Skylab mission, an event occurred that perhaps two years ago would have warranted just as much publicity as the precarious space endeavor. Three nuclear bombs, 30 kilotons of power each, were exploded simultaneously beneath the Rocky Mountains in northwest Colorado as part of an ongoing effort to determine the feasibility of using nuclear power to release the natural gas more than a mile beneath the surface. If analysis of the test, which was codenamed Rio Blanco after the county under which it took place, shows the concept to be favorable, then the event will undoubtedly have a far earlier impact on the man in the street than Skylab.

Both supporters and critics of the nuclear mining business agree that economic acquisition of natural gas by this method will eventually require the explosion of many hundreds of underground nuclear devices; and because the nuclear lobby is promoting the concept as a short-term solution to the energy crisis such explosions are likely to come sooner rather than later.

Rio Blanco was the third of a series of blasts undertaken as part of Project Plowshare, the Atomic Energy Commission's effort to develop peaceful uses for nuclear energy. The two previous tests—Gasbuggy, in December, 1967, and Rulison, in September, 1969—were designed to study the basic technology for nuclear mining, and were set off in areas with relatively little natural gas. Rio Blanco, by contrast, involved an area in which the gas wells are present in profusion; it should therefore give an accurate estimate of the feasibility of the concept for production purposes—although neither the A.E.C. nor the CER Geonuclear Corporation that actually sponsored the test believes that gas from it will yield anything like the $7 million that it cost.

Nuclear Escalation

From this point, the project will undergo a nuclear escalation. Next year or the year after, for example, engineers will fire five nuclear devices sequentially in the same borehole, to produce a much larger cavern than Rio Blanco. And eventually, according to a study by the Lawrence Livermore Laboratory, if any significant proportion of the 3 trillion cubic feet of natural gas locked beneath the Rockies is to be tapped, the nuclear industry will have to set off a mind-boggling 370 nuclear explosions annually until the end of the century—a rate, in other words, of one underground blast a day.

This prospect was understandably more than environmentalists could stomach, and in the year or so before the Rio Blanco test took place a strong protest movement against it was mounted in such centers as Denver and Boulder. To be sure, the critics indulged in little of the environmental doomsaying and legal posturing that had preceded previous underground nuclear explosions, such as Rulison and the A.E.C.'s massive blast beneath the Aleutian island of Amchitka in November, 1971. In the main, the opponents of Rio Blanco set their sights on the possible long-term effects of the tests and its successors, aiming as much to lay the groundwork for convincing protests against the future escalator by blasts as to halt Rio Blanco itself.

In fact this approach was the only sensible course for the environmental lobby. Before the Amchitka experiment the lobby had all but promised destruction of the islands ringing the Pacific, as a result of earthquakes and tidal waves

that would be caused by the blast; when nothing happened in the wake of the explosion it was clear that the A.E.C.'s critics had cried wolf once too often.

Furthermore, both the A.E.C. and CER Geonuclear had obviously learned from the Amchitka blast the value of good public relations. Before the Rio Blanco test they kept residents in the test area in touch with their plans through newsletters and lectures, and even invited them out to see the Las Vegas test site. The publicity worked to perfection; even though many of them had to leave their homes briefly on the morning of the blast, the locals were 100 per cent behind the Rio Blanco project.

The opposition to the test hammered away at two targets: the future hazards caused by Rio Blanco and tests to follow it, and the possible damage to other energy resources.

Water Contamination

One major point was made by geologist David M. Evans of the Colorado School of Mines, who argued that long-lived radioactive by-products of the underground tests might contaminate water from underground aquifers and eventually end up in drinking water taken from the Colorado River and its tributaries. The A.E.C. admitted that contaminated water would be present in the cavity formed by the blast, but noted that it would be covered by steam, which is a barrier to impurities. "We don't see any way for the radioactive substances to get up to the surface and into the water table", declared Dr. Edward Fleming of the A.E.C. Evans remained unconvinced. "If thousands of wells are detonated", he noted, "how can anyone say that water seepage will never occur?"

Other long-range doubts about the outcome of the test appeared less convincing. Thus, the AEC noted that housewives cooking with gas from a nuclear-blasted well would be exposed to less radiation than they would receive on a cross-continental flight, and geological experts tended to dismiss the possibility that a string of underground explosions could trigger major earthquakes.

For the politicians, perhaps the most compelling argument against Rio Blanco was concern that the test might damage the oil shales that lie directly above the blast site, some 1000 feet beneath the surface. Although currently impracticable as an energy source on both economic and environmental grounds, the shales are likely to become more attractive as the energy squeeze continues. Thus any possibility that they might be contaminated with radioactivity or destroyed by "spalling"—the effect of reflection of the shock wave produced by the triple blast from the surface—warranted serious consideration in energy circles. No damage of this sort seemed to occur in the test.

Overall, however, the most effective weapon against extension of Rio Blanco seems to be a general feeling that the A.E.C. is involved in the gas mining business for want of anything better to do with its nuclear devices. Having been turned down on such spectacular projects as nuclear canal building, the agency is virtually putting all its Plow-

share eggs in the mining basket, and paying little heed to the non-nuclear alternatives. A good alternative does in fact appear to be on the horizon, in the form of a technology known as high pressure hydraulic fracturing. This is basically a more powerful version of the conventional hydraulic fracturing, designed to wrest gas from tightly bound formations such as those beneath the Rockies.

For the moment, it appears that the A.E.C. and the nuclear industry has won the first round of the battle. But the environmentalists have handled themselves more responsibly than in the past, and have laid firm foundations for future counter-attacks in what will inevitably become a long-drawn-out war. In the end, the result will probably depend on the public's feeling of how much nuclear pounding it can take. Rio Blanco offered relatively little threat to the local populace. But the industry and the A.E.C. will plainly have to check their homework thoroughly and perform a five-star public relations job to convince the public that hundreds of blasts occurring beneath them each year will represent a solid benefit with an utter minimum of danger.

Formerly Managing Editor of Technology Review, *Peter Gwynne is now Associate Editor of* Newsweek.

Plants and the Urban Ecosystem

Ruth S. Foster

Technology has altered the natural environment nowhere as completely as in the city. The urban ecosystem is a man-made series of relationships totally different from the farming-grazing-hunting areas originally inhabited harmoniously by man and plant.

The basic relationships upon which plants and animals depend have been changed. The city is a virtual desert of concrete, wind, and steel.

Yet plants—and even birds—can serve man predictably in this urban environment if their needs and sensitivities are understood.

Plants, especially trees, affect and ameliorate the climate. Condensation and air currents created by trees in summer can turn the hottest street into a city oasis. They can serve as windbreaks, and they use the pollutant CO_2. More trees would improve the air quality in cities where that is needed most.

More than any other single thing, trees—or their lack—make a city inviting—or dehumanizing. Flowers add cheer, while shrubs and refinements of the landscraper add to the sophistication. But nothing takes the place of trees—the leafy canopy that brings the cityscape into human scale.

To bring living plants and animals successfully into this harsh new environment, we must understand the complex changes which are wrought by urban development.

Natural water circulation patterns are drastically altered, because surface drainage is made efficient and underground aquifers are not recharged. Water tables which nourished trees in time of drought are generally absent. The city habitat is essentially similar to the desert in terms of water runoff and drought between rains.

Urban climates are changed by industry and buildings. Particulate and chemical smog change the temperature and heat retention properties of the atmosphere and alter precipitation patterns. The expected "zone-of-hardiness" changes. The modified rainfall ultimately affects the water cycle of the entire area.

Wind buffets both plant and man on most urban plazas and long avenues. Indeed, the desiccating effect of wind is the severest test city plants must endure, especially evergreen. Hot afternoon sun pockets vie with dank northern corners as inhospitable city microenvironments.

Plant material adapts to a harsh environment or dies. Genetically suitable plants are necessary for urban environments. But a wider choice of greenery is possible if protective microenvironments such as courtyards and low walls are consciously created by planners and architects who understand the outdoor stresses that affect growth and survival.

Water—Too Much and Too Little

More plants die for lack of water in the city than for any other reason. The more surrounding stone and concrete, the more need for supplemental water. Young trees are especially vulnerable. A newly planted tree needs about 1" of rainfall per week, or a supplemental watering of 10 gallons. A two-ft.-square opening in the sidewalk hardly provides enough water to sustain a tree in good health. A better solution is an irrigation system that uses rain water instead of allowing it to run into already overloaded sewers. Even certain clean waste water such as washing water and some industrial wastes could be safely dispersed underground towards tree roots. New thoughts about water reuse are needed.

Often tree plantings are mounded when they should be concave to hold water. Grass rather than concrete highway center strips would help tree health. Roots of trees must breathe. Trees drown in constant puddles, or choke from compression. How many majestic trees can you count today that have been blacktopped right up to the trunks—a sentence of death by desiccation? A ring of stone (or brick set in sand) around such a tree would save it.

City soil is often clay, fill, or rubble. Usual planting procedures place a tree in a 3' deep hole with loam—enough to survive, but not to sustain optimal growth and long life. If such a hole is dug in clay soil the result is likely to be a non-draining tree pit, requiring either drainage or a plant variety that tolerates wet feet. Proper tree pits should be incorporated into building and street plans and filled deeply with good soil.

"More than any other single thing, trees—or their lack—make a city inviting—or dehumanizing."

Reflected sunlight from masonry walls and walks intensifies to desert-like heat. Especially when it is coupled with the wind tunnels that city streets often provide, the drying effect is serious. In addition, sun scorch is a common winter injury. These problems can be avoided by providing artificial shade and utilizing—in the case of sun scorch—the lower angles of the winter sun in northern latitudes.

Soil that has been compacted by machines will not allow for proper root penetration. Physiologically a tree is supported by the air and water near the roots. Trucks driving over the roots of established trees will kill them. Compacted soil supports nothing.

Trees respond to sound and pressure waves, though the question of how this occurs is but a clutter of unscientific opinions. Constant vibration damages plant material, whether it be blasting, drilling, rumbling trucks, or swinging children.

Insects and Diseases

Because the city ecosystem is technologically created, the natural insect balance is non-existent. New landscaping in areas previously devoid of vegetation suffers from what pests are brought in with the new plants or soil, and there is

no likelihood that natural enemies of these pests are available to control them. Unchecked pests multiply, so judicious spraying for recognized pests will keep the city healthy. Broad-spectrum spraying is as deplorable in the city as elsewhere.

To minimize the effects of disease, varied plants should be used so that no one blight will denude a city—as Dutch elm disease has changed so many American cityscapes. Mixing of varieties provides natural barriers to the spread of pests and diseases.

Many substances in urban air and on the street are poisonous to plants. Sodium dioxide, hydrogen fluoride, ozone, nitrogen oxides, ethylene, chlorine, mercury vapor, and oil are a few. Some plants tolerate one, some another; few plants tolerate all. Sodium chloride is a prime despoiler, and we need careful controls to insure highway safety *and* survival of plants. More expensive but beneficial fertilizer salts also lower the freezing point.

If the locust ravages the natural landscape, then it is fair to say that the city's "locust" is the vandal. Science has unravelled the life cycle of the first—but unfortunately not the second. To ignore the vandal in considering urban ecosystems is folly. Protection and replacement allowance are both part of good planning.

The quest for the perfect city plant is endless. There is a plant for every situation. In Africa it may be *albizia grandibracteata,* in New England its relative *gleditsia triancanthos,* in Japan *gingko biloba.* The list is long and contains ample variety. Is a bold foliaged evergreen needed against a concrete wall, a feathery tree to soften a courtyard, or a flower to smile from a hidden corner? A species can be suggested for every purpose.

But every rule about plants has its exceptions. On the Boston Common is a *metasequoia.* It should not survive there in a very foreign habitat in the middle of a northeastern city. But it does.

More scientific experimentation coupled with unconventional boldness is needed for development of plants tolerant of city rigors.

Ruth Schooler Foster is an ecologist with the Boston Parks and Recreation Commission.

Serious Trouble for the A.E.C.?

Book Review:
Henry W. Kendall

The Nuclear Power Rebellion: Citizen vs. Atomic Industrial Establishment
Richard S. Lewis
New York: Viking Press, 1972, 313 pp., $7.95

The Atomic Establishment
H. Peter Metzger
New York: Simon and Schuster, 1972, 318 pp., $8.95

The Atomic Energy Acts of 1946 and 1954 established an Atomic Energy Commission with what amounted to complete control over the development of the energies available from the atomic nucleus for civilian and military purposes. Having a mandate both to promote nuclear power and to regulate it, to design, fabricate, test, and to produce nuclear weapons for the country's strategic and tactical weapons inventories, and to search out and develop other promising applications of the nucleus, the A.E.C. found itself with a charter constructed deliberately to encourage the most rapid exploitation of this new source of energy. It also had the unique capability of acting as its own fiscal authorizing body. On the legislative side, the views and objectives of the Joint Committee on Atomic Energy soon became merged and undistinguishable from those of the A.E.C.

Thus the Atomic Energy Commission, controlling an arcane technology inaccessible to most persons in the government or in the nation at large, and regulated by a Committee whose purposes were indistinguishable from the Commission's, was in a position to operate essentially without inspection or review for many years. It has only slowly become apparent that the broad powers granted the A.E.C. have not been employed uniformly with the restraint that many persons believe is required in the application and control of so potentially hazardous a source of energy as the nucleus. A very substantial opposition has now developed to the national program of power reactor construction based on A.E.C. and industry handling of the program and on the A.E.C.'s behavior in a number of areas.

These issues are the subject of two books. The first, by Richard S. Lewis, a journalist of science who is editor of the *Bulletin of the Atomic Scientists,* is the calmer of the two. Subtitled "Citizens vs. the Atomic Industrial Establishment," it reveals the roots of the widespread protest in the U.S. against the implementation of the A.E.C.'s nuclear reactor construction program. The author is primarily interested in the conflict of interest embodied in the A.E.C.'s mandate and how this conflict has been resolved in favor of the promotion of nuclear power at the expense of important safeguards to the public health and safety.

He shows how the heavy promotional bias and large scale program that has resulted has created what he calls a new Atomic Industrial Establishment, formed of the Joint Committee, the A.E.C., and those industrial firms that construct reactors. He goes on to document the many circumstances that have caused the opposition to nuclear power that we now see, where private groups arise spontaneously to oppose construction and licensing of a majority of new nuclear reactors. He reviews the radiation exposure issue; some elements of the radioactive waste storage controversy; the consequences of the citizen intervention movement; the A.E.C.'s backlash response to citizen interference; several of the ill-considered projects that the

(Continued on p. 74)

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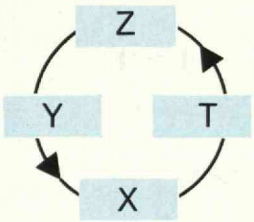

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STO RCL

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- Mixed serial calculations
- Chain calculations
- Mixed chain calculations

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- The reciprocal of the number displayed
- The raising of any positive number to any power
- The factorial of positive integers
- Percentage and percent differences
- Sum of the squares
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- The standard deviation of entries with the "Σ+" key

Automatically convert:
- The decimal angle in any of the angular modes in the display to degrees/minutes/seconds
- The degrees/minutes/seconds angle in the display to a decimal angle
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In three and a half years, astronauts guided lunar modules to six landing sites, took photographs, set out arrays of seismographs and experiments, and collected a total of 381 kilograms of rock and soil. In July, 1969, Apollo 11 landed near the lunar equator on the dark, relatively smooth plain of Mare Tranquillitatis. Apollo 12's site, Oceanus Procellarium, was crossed by a bright ray that streaks southward from the crater Copernicus. The Apollo 13 mission was aborted in flight. Apollo 14 sampled the light-colored Fra Mauro highlands. Apollo 15 landed near Hadley Rille, a canyon-like feature at the base of the Apennine Mountains that rim Mare Imbrium. Apollo 16, which flew to the Descartes Region, was the only mission designed primarily to sample the truly ancient lunar highlands. The final mission, Apollo 17, flew to the Taurus-Littrow region in December, 1972. Meanwhile, the Soviet Union began sending unmanned missions to the moon, including the two small probes of Luna 16 and Luna 20, which returned to earth with a total of 150 grams of soil.

Ursula B. Marvin
Smithsonian Astrophysical Observatory

The Moon After Apollo

Evidence from the Apollo missions indicates that the moon is a small planet with a unique history. We now believe that it accreted near the earth—but apart from it—when the solar system was formed—and that it cooled to geological inactivity three billion years ago.

The past five years have witnessed two revolutionary advances in planetary science. The Apollo missions have prompted a complete reappraisal of our ideas on the character and evolution of the moon, and the theory of plate tectonics has provided a radically new view of the earth. During the same period, the Mariner photographs have revealed previously unsuspected evidence of active volcanism on the surface of Mars, and the study of the Allende meteorite, which exploded as a shower of stones over northern Mexico in February, 1969, has stimulated new insights on the origin of the solar system. A synthesis of data and ideas from all of these sources has yet to be achieved. Lunar scientists are still too preoccupied with eliciting every possible scrap of information from the moon samples to consider the ramifications of plate tectonics, and specialists in plate motions have given relatively little attention to the moon or Mars. But a unified theory of planetary bodies, of utmost importance in understanding our earth, is certain to evolve within the next few years. In this context, what will be the most significant contributions of the Apollo missions?

Some of our hopes and expectations for the program were outlined in my article, "Our Unique Satellite," written before (and revised immediately after) the Apollo 11 landing and published in *Technology Review* for October/November, 1969. At that time, I pointed out that our knowledge of the moon, based mainly on observations of its size, shape, density, surface topography, and orbital characteristics, was so fragmentary and involved so many apparent inconsistencies that two opposed schools of thought were both flourishing. One school maintained that the moon resembles the earth in being a warm, geologically active body with internal convection and volcanic eruptions; the other, that the moon is a cold, primitive meteoritic object which has survived unchanged as a relic of the early solar system. Intermediate views were also expressed—for example, the moon could be meteoritic in composition and partially melted—and such views were generally more popular. But all contenders agreed that the moon is so large a body, and cooling rates of rocky materials are so slow, that if the bulk of the moon has ever heated to the melting point, the interior could not have cooled in the age of the solar system.

The Apollo missions demonstrated that both extreme views of the nature of the moon were wrong, and the consensus on its thermal regime was overly simplistic. The moon is not a warm, volcanic mini-earth, nor is it a cold, primitive meteoritic object. The moon is a third type of planetary body with a complicated history for which we have few familiar guideposts. The rocks of the lunar crust record at least two early episodes of large scale melting and chemical differentiation, but the seismographs monitoring the interior indicate that the moon is now rigid to a depth of about 1,000 kilometers, or nearly two-thirds of its radius. The youngest igneous rocks for which we have age measurements crystallized about 3.2 billion years ago. Thus it seems that, contrary to all expectations, the moon has been hot, but its internal heat engine ran down more than 3 billion years ago, leaving that body geologically inert. Later in this article, we will review the evidence bearing on this hypothesis and on the present status of ideas on lunar origin.

The Moon Before Apollo

Manned exploration of the moon has ended for the time being, but only about five per cent of the lunar rocks and soils have been distributed to date, and all materials not destroyed in the course of analyses are returned to the curator in Houston. Thus, there will be an abundance of moon rock for scientists of future generations, many of whom will have new questions to be solved by new techniques.

For now, we may best assess our newly-won knowledge of the moon and its relation to the earth by reviewing it in context with our older ideas. Our pre-Apollo observations had yielded the following specifications and speculations. The moon has a radius of 1,738 kilometers, and a density of 3.34 gm/cc (the earth's density is 5.52). The moon revolves around the earth once every 27.33 days while it performs one rotation on its axis, which is tilted at an angle of 5.15° to the plane of the ecliptic. As a result of this synchronous motion, the moon always presents the same face to viewers on the earth. That face displays a variegated terrain, two-thirds of which is occupied by light-colored, rugged, heavily cratered highlands, and one-third by

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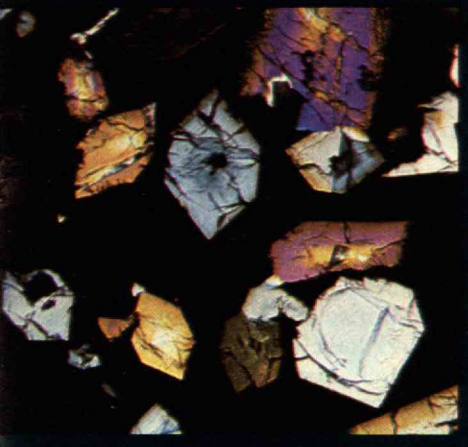
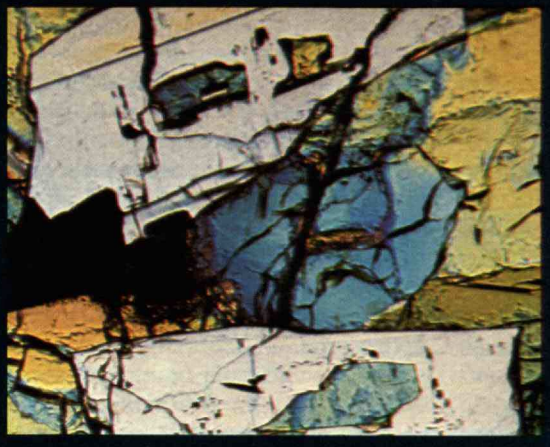
dark, relatively smooth, and sparsely cratered plains, or maria. The maria fill depressions in the highlands, and are therefore younger.

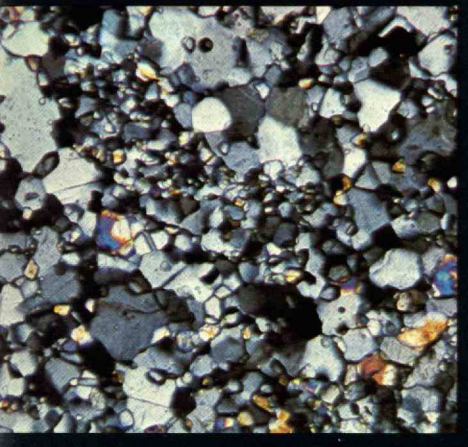
No human had ever seen the back of the moon, or any picture of it, until 1959, when orbital missions were begun, first by the Soviet Union and later by the United States. To the surprise of all scientists, schooled in the principle of uniformitarianism, the first pictures showed the far side of the moon to be entirely covered by highlands pitted by only a few small, circular maria. The moon's surface is therefore markedly asymmetrical. Perhaps in retrospect this discovery should not have seemed so surprising. The surface of the earth is equally asymmetrical; our light-colored, high-standing continents occupy only 30% of the earth's surface, and most of them are crowded toward the northern hemisphere, whereas the dark, depressed floors of the oceans occupy the remaining 70% of the surface.

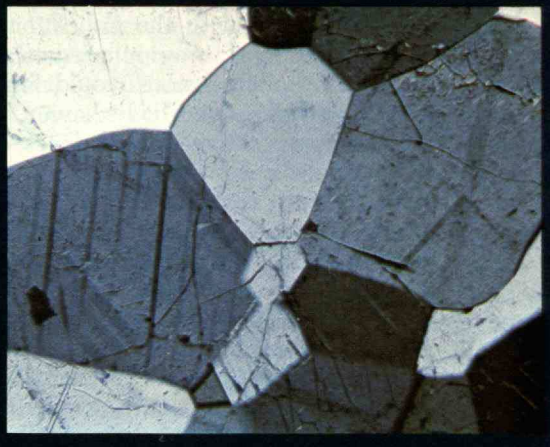
Asymmetry might be a normal condition of planetary surfaces. In 1972, the Mariner IX pictures of Mars revealed that one side of that planet appears geologically inactive and pockmarked by meteoritic impact craters, while the other side supports at least one gigantic active volcano. However, as will be discussed below, the surfaces of the moon, the earth, and Mars have entirely different histories.

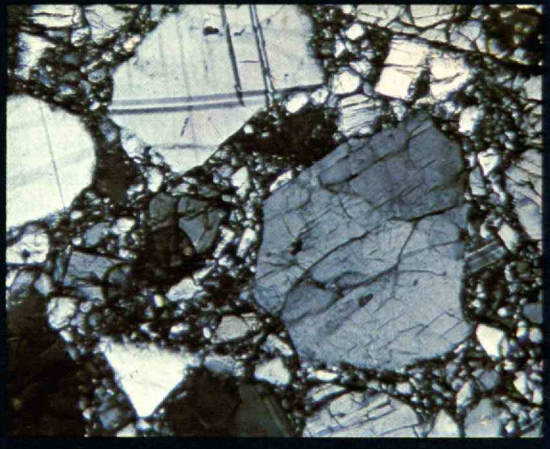
The earth and moon are locked into a dynamic relationship, unlike any other in the solar system, in which the satellite possesses greater orbital angular momentum than the rotational angular momentum of its planet. The moon now has a mean distance of 384,400 kilometers from the earth and is retreating in an ever-widening orbit while, to conserve angular momentum, the earth's rate of rotation is gradually slowing down and lengthening our days by 1.8 milliseconds per century. Calculated backward, the present rate of retreat would have the moon within 2.89 earth radii about 1.5 billion years ago. That distance is the critical Roche limit at which the two bodies should disrupt one another catastrophically, the moon raising enormous body and ocean tides on the earth, the earth fragmenting the surface of the moon and bringing down upon itself a storm of large











Rocks from the Moon
Opposite page, top photograph: basalts—volcanic rocks rich in iron-magnesium-silicates—which are typical of the lunar maria. Divisions of the scale in the photograph are in millimeters.
Bottom photograph: anorthosites—igneous or metamorphic rock composed almost entirely of the mineral plagioclase feldspar—which are typical of the lunar highlands; again, the divisions are in millimeters.
This page: thirty-micron-thick sections of lunar rocks, photographed in polarized light except where noted. The horizontal field of view in all photographs is three-quarters of a millimeter.
Top row: basalts. At the left, crystallization of the mineral pyroxene out of a glassy matrix (which is opaque under polarized light) was interrupted by quenching. The basalt at the right is completely crystallized: white areas are feldspar, opaque areas as ilmenite, and the rest is olivine.
Second row: anorthosites. The one at the left is composed of plagioclase with small grains of olivine, the coarser one at the right is entirely plagioclase.
Third row: breccias—rocks composed of fragments. The one at the left (in partially polarized light) is a "soil breccia," formed from a wide assortment of materials, while the one at the right, composed of large fragments of feldspar and pyroxene embedded in a matrix of the same composition, is a norite.
Bottom row: glass spherules, in unpolarized light. Left, specimens from the famous orange soil found by Apollo 17 astronauts. Small crystallites have formed in the glass; the opaque ones are ilmenite, the colorless ones olivine. Right, green glass from Apollo 15.
All photographs are from the Smithsonian Astrophysical Observatory; those on this page were taken by the author.

and small debris. Neither the geological record of the earth, nor our present knowledge of the lunar surface, allows for such a cataclysmic event at so late a date. Therefore the moon's rate of retreat cannot have remained uniform.

There is no doubt, however, that the moon has been closer to the earth in the past, and this fact has been used as an explanation for the moon's out-of-shape figure. The moon's motions suggest that it is a triaxial ellipsoid with an excess equatorial bulge about one kilometer high aligned with the earth. The "bulge" is a feature of the moon's gravitational field, but for the past 50 years, it has been widely interpreted as a fossil tidal bulge in the rock that was formed and frozen in when the moon was much closer to the earth and rotating more rapidly. An alternative (but less popular) explanation was that the moon is inhomogeneous and has an excess of high-density material within the earth-facing hemisphere. Either interpretation requires that the moon has sufficient internal strength and rigidity to preserve a disequilibrium figure throughout much of geologic time.

New evidence for internal strength was discovered in 1969, when the paths of the Lunar Orbiter satellites revealed the presence of positive gravity anomalies associated with all the large circular maria of the earth-facing side. The anomalies indicated that these basins support mass concentrations (mascons). In pre-Apollo days, three explanations were proposed for mascons: the infall and burial of heavy meteoritic bodies, the addition to the basins of dark, carbonaceous lake sediments, or the addition of basaltic lava flows. Regardless of their cause, it seemed that the mascons should have been eliminated by isostatic adjustment to gravitational equilibrium, unless they are of recent origin or are old features that are maintained by the strength of the interior.

The moon lacks an atmosphere detectable by optical or radio observations either from the earth or from the Explorer satellites. The moon is therefore not continually losing gases as is the warm, volcanic earth. If it were, the heavier gases—those having a molecular weight over 16—could be trapped for significant amounts of time despite the moon's low gravitational field. The absence of any permanent gaseous envelope has been taken as evidence that the moon has a cold, inactive interior.

Three lines of evidence militated against the presence of an iron core in the moon. The pre-Apollo calculated moment of inertia of 0.41 indicated a homogeneous body; the moon's low density indicated an impoverishment in metallic iron; and the lack of a magnetic field ruled out the possibility that the moon maintains a self-generating electromagnetic dynamo.

The specifications outlined above are readily seen to involve contradictory evidence on the nature of the moon. Scientists who were impressed mainly with the indications of a cold, rigid interior predicted that the Apollo missions would find a relatively primitive body having a similar composition to chondrites—stony meteorites which have never melted—and a surface topography sculpted solely by the impact of bodies from space. They outlined a history in which, at an early period, a succession of "moonlets" tens of kilometers in radius excavated vast basins such as those of Serenitatis, Crisium, Imbrium, and Orientale, and a bombardment of smaller bodies ranging down to tiny particles of cosmic dust has continued to the present. According to this school of thought, a byproduct of the bombardment is the lunar regolith, an unconsolidated layer of boulders and soils that blankets the entire surface of the moon. Proponents of a cold moon viewed the lunar maria as either remnants of ancient carbonaceous meteoritic materials or deposits of finely pulverized dust that migrated downslope from the highlands by electrostatic processes.

An opposed school of thought depicted the moon as a geologically active body. Its surface formations are of two dominant colors and stand at two mean elevations, as do those of the earth, and many geologists interpreted them as products of magmatic differentiation: light siliceous crust analogous to earth's continents overlying a deeper layer of dark "oceanic" basalts. The lunar maria have wrinkled ridges and lobate margins like those of lava flows, and some lunar craters mimic the forms of volcanic calderas. The rilles of the moon follow meandering paths suggesting the work of running water. Those advocating an igneous moon pointed out that if that body were as rich in radioactive elements as either the earth or chondritic meteorites, it could not have escaped internal melting.

Beyond the immediate problem of the composition and thermal history of the moon, a most intriguing question is why the earth has a moon at all. In the inner solar system, Mercury has no moon, Venus has none, and Mars has two moons, each the size of a small rocky island less than three kilometers in radius. The wide gap between Mars and Jupiter is sparsely populated by thousands of asteroids, the largest of which, Ceres, is only 384 kilometers in radius. All of the asteroids together would make up one body no larger than about three per cent of the mass of our moon. The giant icy planets of Jupiter and beyond all have moons that are infinitesimal in comparison with their own masses. But our moon is one-quarter as large as the earth itself. Thus, small as it looks to us in the night sky, the moon, by solar system standards, is an immense satellite that renders the earth-moon pair unique.

Three hypotheses have been proposed to account for the moon:

☐ The moon was ripped away from the earth at some early period;

☐ The moon formed elsewhere in the solar system and was captured during a close encounter with the earth; or

☐ The moon accreted as a separate body in the vicinity of the earth.

All three possibilities pose severe dynamic problems, and each one can be countered by persuasive objections. It is small wonder that the moon has always been far more mysterious to scientists than it ever was to poets.

Lunar Rocks and Minerals

One major controversy was settled while the Apollo 11 astronauts were still on the moon. The lunar maria are lava flows reminiscent of the earth's eruptions of fissure basalts. When they were examined in the laboratory, the mare rocks proved to have basaltic textures, but they differ chemically from terrestrial basalts in several important respects. They are richer in iron and poorer in silicon, and are therefore less viscous than terrestrial basalts. Lunar flows have been traced for distances of over 350 kilometers on slopes of less than 1°, and there are indica-

tions that some flows may have persisted for more than 1000 kilometers. The lunar basalts are also characterized by extraordinarily high values of refractory elements, chiefly titanium, zirconium, chromium, and rare earth elements, by low values of volatile elements such as sodium, potassium, and rubidium, and by a complete absence of ferric iron and water. Due to the lack of water and free oxygen to produce clay and rust, the minerals are as fresh and glistening as the day they crystallized. And for the Tranquillitatis basalts, that "day," according to age measurements by the Rb/Sr method, occurred about 3.7 billion years ago.

Those first basaltic samples established beyond all doubt the fact that igneous processes have occurred on the moon, on a grand scale and at a very early period. Even then, however, the moon was so impoverished in volatiles that no water was available to form (OH)-bearing minerals in the basalts, much less to generate an enduring atmosphere or any lunar rivers or lakes. The enrichment in titanium rendered the Apollo 11 basalts so heavy with the mineral ilmenite ($FeTiO_3$) that they range in density from about 3.3 to 3.5 gm/cc. Some of them are therefore denser than the moon itself. Obviously the interior of the moon cannot contain any significant proportion of such rocks, which, at a depth of about 300 kilometers, would compress under pressure into materials of even higher density.

Perhaps it should be emphasized that none of the samples collected by the astronauts on any mission were taken directly from lunar bedrock. They were obtained from the boulders or soils of the regolith, which proved to be a very complex layer of rock fragments, dust, and glass. In pre-Apollo days, it was widely assumed that much regolith material would be transformed beyond recognition by the combined effects of impact shock and intense cosmic radiation. Fortunately for petrologists, shock and radiation effects are present in sufficient abundance to yield interesting data to those specializing in their study, but the majority of the rocks and minerals have survived relatively intact.

Two of the most common types of regolith particles are glasses and microbreccias. In the Apollo 11 samples, glass made up more than half of the material in the less-than-one-centimeter size range. The glass occurs as beautifully formed spherules that are predominantly golden yellow through bright orange to deep amber, and chemically equivalent to titanium-rich basalts. Less common spherules are colorless, pale yellow, pale blue-green, deep red, or opaque black. Glass also occurs as brown, flowbanded, vesicular cinders, as irregular masses splashed on rock surfaces, and as a welding agent in the soils. A special mode of occurrence with no equivalent in the earth's crust was found in the so-called zap pits, which mark all rock surfaces that lay on the moon in positions exposed to outer space. Zap pits are small, circular, glass-lined depressions, ranging in size from a few microns to about two millimeters. They are caused by the impact at cosmic velocities of tiny particles that destroy themselves as they pit and melt the target material. The colors of the glassy pit-linings proved to be an invaluable guide to the astronauts in judging the approximate composition of many otherwise dust-covered lunar rocks.

Impacting objects not only pit, crush, and destroy rocks, they can also create them. The microbreccias of the regolith are an example. These breccias consist of bits and pieces of rock and glass from diverse sources, compacted or welded into more or less cohesive aggregates. The breccias result from shock lithification or impact melting, and sometimes include as many as two generations of older microbreccias, thus recording a history of successive fragmentation and reaggregation of materials.

When bulk samples of the Apollo 11 regolith were dated by the whole rock Rb/Sr method, they yielded a so-called model age—an age calculated on the assumption that the strontium in the material being dated had an initial isotopic ratio similar to that of primitive solar system strontium as measured in certain 4.6 billion year old meteorites—of about 4.6 billion years. Inasmuch as a "soil" cannot be older than the underlying bedrock, which was 3.7 billion years old, these age relationships constituted a most puzzling anomaly.

About 4 per cent of the fragments in the Apollo 11 soils were white particles that, when examined under the microscope, proved to be finely textured rocks consisting of over 70 per cent calcium-rich plagioclase feldspar with a few per cent of the minerals olivine and pyroxene, and sparse grains of metallic iron. The white rocks differed in details of their chemistry from any known terrestrial rock. However, their closest equivalent, mineralogically, are the anorthosites—large, enigmatic bodies of igneous or metamorphic rock within the ancient Precambrian shields of the earth's continents. Early in the investigations, it seemed possible that the lunar "anorthosites" might represent segregated layers that formed within the mare basalts—an idea that later proved untenable on grounds of an incompatible sequence of crystallization. From the first, however, certain investigators, notably John A. Wood of the Smithsonian Astrophysical Observatory, remembered that ballistics calculations, published by Eugene A. Shoemaker of the California Institute of Technology, had indicated that the Apollo 11 soils should contain about four per cent of particles projected there from the lunar highlands. If by any chance the white particles were highland rock, then the lunar highlands are anorthositic (at least in part), and that was one type of composition that had never been predicted by any scientist. Granites, rhyolites, peridotites, chondrites, enstatite achondrites, and tektites had all been proposed as possible relatives of the rock of the lunar highlands, but never anorthosites. When the broadly anorthositic character of the lunar highlands was confirmed by later Apollo missions, it came as a stunning surprise to geologists and sparked a widespread interest in terrestrial anorthosites. Suddenly these rocks, formerly more or less regarded as scientific curiosities and left to the attention of a few specialists, were seen as possibly our best clue to the nature of the earliest crust of the earth.

A new and important rock type was discovered on the Apollo 12 mission to Oceanus Procellarum. At that site, the mare basalts were less enriched in titanium than those of Apollo 11 and were 500 million years younger, with a crystallization age of 3.2 billion years. However, the light-colored particles in the dark soil were not white but gray, and they contained less feldspar and more pyroxene and ilmenite than the Apollo 11 anorthosites. Most of the

pyroxenes were calcium-poor orthorhombic crystals, a characteristic constituent of the igneous rocks called norites. Technically speaking, anorthosites, norites, and troctolites (rocks consisting mainly of plagioclase feldspar and olivine) are all subspecies of deep-seated rocks called gabbros, and basalts are the volcanic equivalent of gabbros. The commonest lunar rock types therefore span a very narrow compositional range. (The transference of these names from terrestrial to lunar rocks, which differ somewhat from their namesakes in grain size, textures, and chemical composition, has met with determined opposition from conservative geologists. However, used in a broad mineralogical sense, the names have become entrenched in the scientific literature.)

The Apollo 12 norites were seen, under the microscope, to contain zircon and phosphates as accessory minerals. Accordingly, chemical analyses showed a marked enrichment in zirconium and phosphorus as well as other elements (uranium, thorium, rare earths) that are commonly concentrated in these minerals. The Apollo 12 soils also yielded a new variety of glass in small, ropy fragments looking much like miniature chunks of pulled taffy coated with fine gray dust. The glass proved to be very rich in potassium (K), rare earth elements (REE), and phosphorus (P); hence the acronym KREEP. That term, first used for the glass by Charles Meyer and his colleagues at the Johnson Space Center in Houston, was presently extended to other materials of similar minor element composition. These include certain (but not all) crystalline norites, certain (but not all) light-colored glass-matrix breccias, and one type of interstitial residuum that occurs in some basalts. Two unusual rock specimens—Luny Rock I from the Apollo 11 site, and Rock 13 (12013) of Apollo 12—and most of the materials collected on the Apollo 14 mission to the Fra Mauro highlands are KREEP-rich.

The genesis of KREEP is controversial. The material is so radioactive that it could hardly be a major component of the lunar interior without causing large-scale melting. In general, KREEPiness seems to be characteristic of the Fra Mauro formation, a deposit of fragmental rock interpreted as impact ejecta from the Imbrium basin. Such material probably underlies the basalts of Oceanus Procellarum and is assuredly abundant at the site of the Crater Copernicus in the southern rim of Mare Imbrium. A ray from Copernicus streaks southward across the Apollo 12 site where the astronauts found the dark regolith banded with gray soils both on the surface and in the walls of a trench they dug. The gray component of these soils proved to be the ropy KREEP glass. That observation not only traces one type of KREEP to the Imbrium region, it also provides information on the nature of the lunar rays which, in this case at least, are wispy deposits rich in particles of impact-melted glass coated with crystalline feldspar-pyroxene dust.

Gamma-ray recorders orbiting the moon on the Apollo 15 and 16 missions located a single large radioactive high centered on the region of Mare Imbrium and Oceanus Procellarum. This observation, reported by James Arnold of the University of California at San Diego, indicates that the moon is asymmetrical in chemical composition as well as in its figure and its surface topography. The large volume of radioactive KREEP in the northwest quadrant of the moon has been ascribed either to non-homogeneous accretion accomplished by the infall of a KREEP-rich moonlet (which only defers the problem of KREEP genesis to an earlier stage), or to the localized formation of a KREEPy magma as the low temperature fraction of a very large differentiation system—with no satisfactory explanation of why the process should have been localized. Regardless of how or when they originally crystallized, the KREEP-rich Fra Mauro rocks are now breccias that last annealed about 3.9 billion years ago. The annealing event is widely assumed to have been the impact-sculpturing of the Imbrium basin.

As noted above, not all norites are KREEP-rich. The predominant nonmare rocks collected on all missions except Apollo 12 and 14 belong to a series of anorthosites, norites, and troctolites (nicknamed the ANT suite) impoverished in KREEP components. The ANT rocks have all been brecciated and recrystallized to varying degrees, but their compositional trends suggest that they originally formed as a layered sequence by gravitational separation from a single magma.

A discovery of special importance was made on the Apollo 16 mission to the Descartes highlands. At that site, ANT rocks occur as fragmental inclusions within light-colored, porous, slightly annealed breccias that appear to have aggregated in an ancient highlands regolith. Age measurements, by the $^{40}Ar/^{39}Ar$ method, reported by Liquat Hussain and Oliver Schaeffer of the University of New York at Stony Brook, show that the breccias annealed between 4.1 and 4.25 billion years ago. These breccias are the oldest dated rocks in the lunar samples, and therefore the angular fragments of ANT rocks within them, although of undetermined age, are even older. Clearly, the anorthosite-norite-troctolite suite is among the earliest components of the highlands crust. (These rocks have proved to be of such significance that the Descartes mountains have informally been christened the ANT hills.)

In addition to the rocks of broadly gabbroic composition (basalts, anorthosites, and norites), the lunar samples contain less abundant varieties, including granites and dunites. The granites (or rhyolites) are sparsely represented by a few fragments in the soils, by the light-colored portion of Rock 12013, and by glassy interstitial redisua in some of the mare basalts. The latter type of occurrence came as no surprise to those geologists who believe that granites are an end product of basaltic crystallization. However, to others, schooled in the concept that the earth's continents consist largely of transformed sediments, it has been educational to observe that granitic melts actually are possible in systems devoid of the erosion-sedimentation cycle. On the moon, however, fractional crystallization does not seem to have produced any significant volume of granite.

The rare examples of lunar dunite, a rock consisting wholly of olivine, occur mainly as inclusions in breccias. The dunites presumably derive from a deep layer of the moon's interior.

Some lunar rock types are represented in the Apollo samples solely as glass. The most striking example was discovered on the Apollo 15 mission: soils abounding in billions of bright emerald green glass spherules which have a uniform composition equivalent to that of a rock relatively rich in iron and mag-

Abundant	
Pyroxenes	$(Mg,Fe,Ca)_2(Si_2O_6)$
Plagioclase	$(Ca,Na)\ (Al,Si)_4O_8$
Olivines	$(Mg,Fe)_2(SiO_4)$
Accessory	
Ilmenite	$FeTiO_3$
Chromite	$FeCr_2O_4$
Ulvospinel	Fe_2TiO_4
Spinel	$MgAl_2O_4$
Cr-pleonaste	$(Fe,Mg)\ (Al,Cr)_2O_4$
Perovskite	$CaTiO_3$
Dysanalyte	Ca,REE,TiO_3
Rutile	TiO_2
Nb-REE-rutile	$(Nb,Ta)\ (Cr,V,Ce,La)TiO_2$
Baddeleyite	ZrO_2
Zircon	$ZrSiO_4$ + REE,U,Th,Pb
Quartz	SiO_2
Tridymite	SiO_2
Cristobalite	SiO_2
Potash Feldspar	$KAlSi_3O_8$ + Ba
Apatite	$Ca_5(PO_4)_3(F,Cl)$ + REE,U,Th,Pb
Whitlockite	$Ca_3(PO_4)_2$ + REE,U,Th
Zirkelite	$CaZrTiO_5$ + Y,REE,U,Th,Pb
Amphibole	$(Na,Ca,K)\ (Mg,Fe,Mn,Ti,Al)_5Si_8O_{22}(F)$
Iron	Fe
Nickel-iron	(Fe,Ni,Co)
Copper	Cu
Troilite	FeS
Cohenite	Fe_3C
Schreibersite	$(Fe,Ni)_3P$
Corundum	Al_2O_3
Goethite	$HFeO_2$
New minerals	
Armalcolite	$(Fe,Mg)Ti_2O_5$
Tranquillityite	$(Fe,Y,Ca,Mn)\ (Ti,Si,Zr,Al,Cr)O_3$
Pyroxferroite	$CaFe_6(SiO_3)_7$

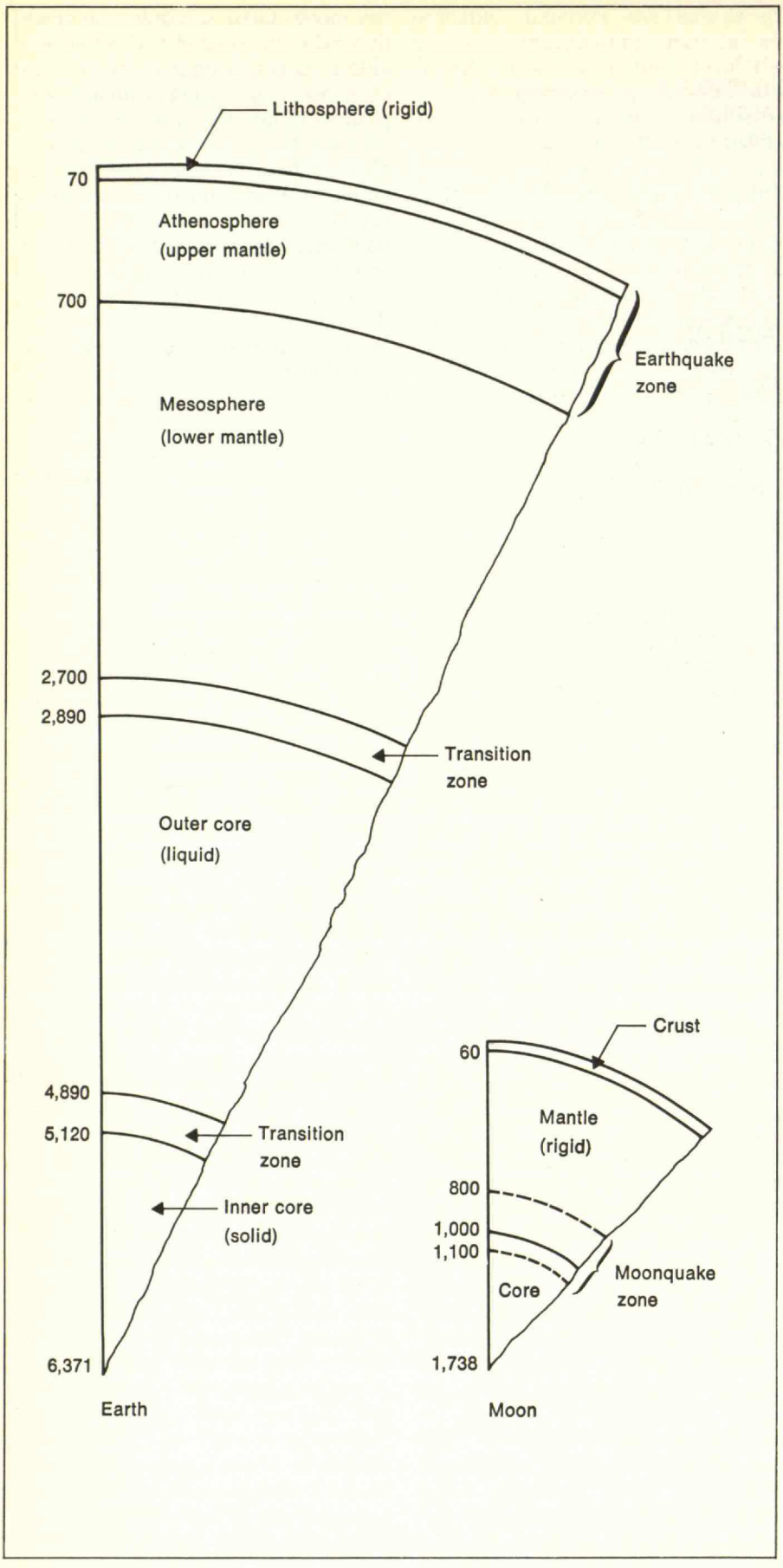
The lunar minerals. An addition sign (+) indicates minor or trace elements that tend to concentrate in a given species; REE is short for rare earth elements. The three new minerals were all found on the Apollo 11 mission to Mare Tranquillitatis. Armalcolite was named in honor of the Apollo 11 astronauts ARMstrong, ALdrin, and COLlins, and Pyroxferroite earned its ungainly name for a similarity to an earthly mineral, pyroxmangite, which contains manganese rather than iron.

nesium and poor in aluminum, titanium, sodium, and potassium. No crystalline rock of this composition has been returned from the moon, but it assuredly must occur as a major formation somewhere in the vicinity of the Apennine front. Possibly it represents lunar mantle rock.

The most famous of all lunar samples was without doubt the orange soil collected on the Apollo 17 mission. This material, discovered on the rim of Shorty—a small, fresh-looking, sharply-delineated crater—excited visions of fumarolic activity releasing water, iron oxides, and perhaps sulfur. Avid for evidence of young volcanism on the final mission, geologists around the world temporarily forgot their experience with the Apollo 11 soils and so allowed themselves to be taken by complete surprise when the final mission's samples yielded myriads of spherules of orange glass that is 3.7 billion years old. Such glass has the composition of a titanium-rich basalt, and indeed many of the spherules are black with tiny crystallites of ilmenite. The preservation of glass billions of years old is one more indication of the extreme dryness of the moon. Glass devitrifies so readily in the presence of water that the oldest remnants of it in the earth's crust occur in volcanic ash beds deposited about 100 million years ago.

It is easy enough to envision how glass spherules may be created either by volcanism or impact melting. It is much harder to imagine how vast numbers of them may be concentrated to form a thick, unconsolidated layer. Photographs of the orange-soil site show two other exposures of orange soil nearby. One is within the walls of Shorty crater, the other on the rim. To account for the orange spherule deposit, Edward Roedder of the U.S. Geological Survey has combined two familiar theories and proposed that 3.7 billion years ago an impacting meteorite or comet plunged into a basaltic lava lake and splashed out an enormous volume of droplets that quickly quenched to glass. Soon afterward, the glassy deposit was covered by another layer of material and thereafter protected from mixing and gardening. Thirty million years ago, another meteorite excavated Shorty crater and exposed some of the orange glass to cosmic radiation. There it remained until last December, when it was collected by the astronauts.

The lunar minerals identified to date are listed in the table on this page. Their number, which includes three hitherto unknown species, is very small compared with the 80 or so species found in meteorites, and the more than 2,000 known on earth. The formulas illustrate the overall richness in calcium, magnesium, iron, titanium, zirconium, uranium, thorium, and rare earth elements. A reduced state of oxidation is signaled by the presence of metals, a carbide, and a phosphide, and by the absence of ferric iron. As we have noted, the lunar minerals, with rare exceptions, are unaltered by oxidation. The exceptions consist of small spots of rust observed on grains of metallic iron in a few rock and soil fragments. The cause of the rust remains unknown. It has been attributed to the action of moist air on unvacuum-packed samples after splashdown in the Pacific Ocean or to the volatiles released by the impact of an icy comet fragment on the lunar surface. The argument for comet impact is strengthened by measurements made by Everett K. Gibson at the Johnson Space Center



Sections of the earth (left) and the moon (right), drawn to the same scale. Depths beneath the surfaces are in kilometers. External forces appear to cause moonquakes, which tend to be correlated with the apogees and perigees of lunar orbits around the earth and the sun. Earthquakes are apparently generated by internal forces—the motions of the earth's crustal plates.

of the pattern of volatiles released in trace amounts during heating of certain lunar soils. The volatiles include species observed in comet spectra.

Although the lunar materials show only the faintest traces of chemical alteration, all of the anorthosites, norites, and troctolites show textural evidence of recrystallization, with or without partial melting since they were first formed. Many of them are breccias consisting of angular clasts of rock that was crushed *in situ* and then welded in a matrix of finely crystalline or glassy material. Others have completely recrystallized to polygonal textures.

One of the coarsest grained anorthosites is the Genesis Rock collected on the Apollo 15 mission by astronauts schooled to look for white rocks as samples of the most ancient lunar crust. When it was collected, the Genesis Rock was indeed the oldest rock from the moon, dated at 4.05 billion years. Nevertheless it was mistitled: it was not a relic that survived unaltered from the time of genesis of the moon.

What do we mean when we refer to a lunar event as ancient or recent? The ultimate measure is the age of the solar system which, from U/Pb determinations on meteorites and terrestrial rocks, is established at about 4.6 billion years. Such a date means that 4.6 billion years ago, the earth and the meteorites' parent bodies began to act as closed systems with respect to the decay of uranium and the build-up of radiogenic lead. The age of 4.6 billion years is confirmed for meteorites by both the Rb/Sr and the K/Ar dating methods. The oldest rocks discovered in the earth's crust record a cooling event that took place about 3.7 billion years ago. Therefore the tangible record of the first billion years of our history, which was undoubtedly marked by extensive recycling of crustal rocks, has been lost to us. The lunar materials yield model ages of 4.6 billion years, demonstrating that that body also achieved a separate identity at the birth of the solar system. But as we noted earlier, the oldest dated rocks in the lunar samples are breccias that annealed about 4.2 billion years ago. Therefore the direct record of the first 500 million years of lunar history is lost to us. Before attempting to reconstruct the events of that period and subsequent lunar history,

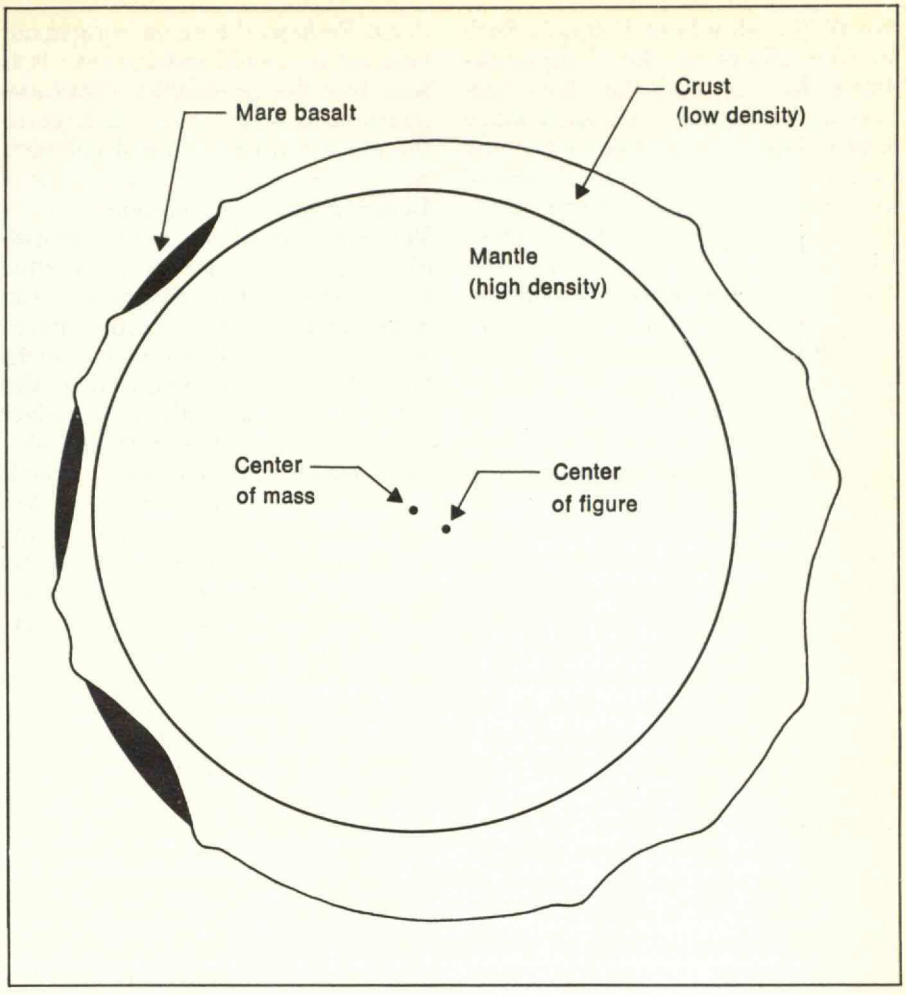
let us examine the new evidence respecting the nature of the moon's interior.

The Lunar Interior

Despite the lack of a present day magnetic field, all of the lunar rocks show a clear paleomagnetic record of having cooled and crystallized in a field varying in strength and as high as 3,000 gammas. Clearly, the infant moon evolved in the presence of a magnetic field that persisted for at least 1.5 billion years until the youngest of the mare basalts had consolidated. Was the source of the ancient magnetic field internal or external to the body of the moon?

Seismic signals, which are still being returned from the network of five stations emplaced on all missions except Apollo 11, show that the moon is a layered body with a rigid crust, about 60 kilometers thick, overlying a rigid mantle that extends to a depth of about 1,000 kilometers. Beneath the mantle is a core that damps out shear waves generated by farside meteorite impacts and is therefore at least partially molten. The discovery of a core was unexpected indeed by those scientists who remembered the moon's low density, its lack of a present magnetic field, and its out-of-shape and presumably cold body. Once the evidence for a core was detected on the seismograms, it was interpreted by some geophysicists as a nickel-iron body too small to raise the bulk density of the moon and too quiescent to generate a magnetic field today, but formerly active enough to account for the remanent magnetism of the surface rocks. Others postulate that the core is not metal but partially molten silicate rock at a temperature of about 1,500°C. They are forced to ascribe the remanent magnetism to an external field imposed upon the ancient lunar surface either by an expanded field of the earth or by some special conditions of solar field electromagnetism. Either interpretation requires that when the lunar surface rocks cooled through the Curie point, the temperature at which a cooling rock would acquire its magnetism, the interior of the moon was too hot to be magnetized or has subsequently heated enough to lose its magnetism.

The two major discontinuities in the moon occur at the base of the crust and the base of the mantle.



A grotesquely out-of-scale lunar cross-section, to emphasize the moon's out-of-shape figure: The moon's center of mass is about two kilometers closer to the earth than its center of figure. The apparent explanation is that the anorthositic crust on the side of the moon facing the earth is much thinner than that on the farside—thin enough so that dense basaltic lavas from the lunar interior could fill the nearside's basins, creating the dark-colored maria strangely absent on the farside of the moon.

Most of the moonquakes recorded to date have occurred near the latter discontinuity, at depths of 800 to 1,100 kilometers. The moonquakes are weak (of magnitudes less than 2 on the Richter scale) but they are not sporadic. They occur most frequently at monthly intervals correlating with the apogee and perigee of the lunar orbit around the earth. There is also a 207-day cycle corresponding with one period of the solar tides. The conclusion seems inescapable that tidal stresses on the body of the moon generate quakes in a zone of weakness between the mantle and core. Thus, unlike earthquakes, which are caused by crustal plate motions driven by thermal energy from our planet's unquiet interior, moonquakes arise from an externally imposed force.

New information on the moon's figure, obtained by laser altimeter readings on the Apollo 15, 16, and 17 missions, show that the moon's center of mass lies about two kilometers closer to the earth than its center of figure. It now appears that the offset can most readily be explained by the observation that the moon has twice as great a thickness of low-density highlands crust on the farside and a greater mass of high-density rock in the nearside. At least three possible causes have been suggested for such gross inhomogeneity: an original accretion of dissimilar materials; the presence of a thermal convection cell with a rising limb under the nearside; or a systematic stripping away of the highlands crust from one side and its redeposition on the other during an early period of earth-focused bombardment. In any case, theoretical support for the idea of a frozen lunar tidal bulge was removed in March, 1973, when a newly recalculated value of 0.395 for the moment of inertia was reported

by William Kaula of U.C.L.A. Such a value allows for the observed internal layering and the offset centers of figure and mass in a moon that is largely in a state of isostatic equilibrium, precluding frozen-in features. The dramatic local anomalies associated with the mascons are no longer believed to mark the sites of buried meteoritic bodies. They are now generally seen as uncompensated masses of basalt which filled the basins to the level dictated by isostasy while they were liquid and then cooled to denser solids at a time when the crust was too rigid to subside beneath them.

Faint traces of a lunar atmosphere were detected by a mass spectrometer emplaced at the Apollo 17 site, and gases of past atmospheres have been discovered in the course of controlled heating experiments on lunar soils and breccias. The gases, however, are mainly radiogenic species such as ^{4}He and ^{40}Ar. The mass spectrometer shows that the light atoms of ^{4}He are about 20 times more abundant at the surface during the two-week lunar night than they are in the daylight, when they are present in concentrations of about 3,000 molecules per $cm.^{3}$ The concentration of ^{40}Ar, however, decreases strikingly at night and rises again a few hours before sunrise. The argon is evidently adsorbed on the soils at night and released again to sweep around the moon ahead of sunrise. The tenuous lunar atmosphere apparently consists mainly of gases implanted on the surface by the solar wind. It carries none of the common molecules of hydrogen, oxygen, sulfur, nitrogen, carbon, or chlorine that are so abundant in the volcanic emanations of the earth.

Although both are layered bodies, the moon and the earth contrast sharply in their character and evolutionary history. The moon is rigid for the outer 60 per cent of its radius, the earth, for the outer one per cent. If the moon's internal structure derives from melting and differentiation, how can so large a body be rigid to so great a depth? Possibly we have misread the meaning of rigidity. A warm interior (or a highly radioactive surface layer) was indicated by the heat flow measurements of 2.8 microwatts per $cm.^{2}$ made on the Apollo 15 and 17 missions. But internal heat in the absence of water and other volatile fluxing agents may not produce plasticity. Perhaps the moon is rigid not because it is cold but because it is dry. But that possibility raises the question of how a body as large as the moon can be so free of volatiles.

Lunar Origin and Evolution

The character of the moon's crustal rocks and its interior structure have forced many second thoughts on the origin and evolution of the moon, and, indeed, of planetary bodies in general. We now know that the moon differs markedly in chemical composition from the earth and also from chondritic meteorites, which are the closest approximation we have of primitive materials resembling the condensed elements in the sun. Although few theories ever die completely, the majority of lunar scientists have rejected both of the older ideas that the moon was ripped from the earth or that it is a meteoritic body captured from the asteroid belt. Attention is now focused on the problem of how two dissimilar bodies could simultaneously grow by accretion in the same region of the solar system.

The dynamic constraints are considerable because, as the larger body grows and develops an ever stronger gravitational field, the smaller one must speed up and move outward in its orbit. Possibly the moon was not orbiting the earth while it grew but was captured soon afterward from a solar orbit. On the other hand, the tilt of the axes of the moon and the earth may indicate the former presence of many perturbing objects that influenced the growth and orbital paths of both bodies.

The chemical aspects of accretion pose another problem. One traditional view holds that, although the earth and moon differ somewhat in bulk composition, each body was homogeneous when it attained its present mass. Subsequently, each one has melted completely and undergone a giant smelting operation in which heavy metals sank to form a core, and light materials floated to the surface, leaving an intermediate mantle of dense ferromagnesian silicates. A new view is that both the earth and moon grew by the accretion, layer by layer, of dissimilar materials and that neither body has ever been completely melted at any one time. The gross chemical differences between the earth and moon and the internal layering of each are thus explained as primary features, howevermuch the layers may have been altered by local melting, mixing, or phase changes since the beginning.

Inhomogeneous accretion in the solar system is by no means a new idea, but it was given new impetus by the fall of the Allende meteorite early in 1969. That event strewed more than a ton of small fragments over a large, populated area of southern Chihuahua, Mexico, where they were quickly collected. Many of the scientists who obtained Allende specimens were preparing to receive the Apollo 11 samples later in the same year. Allende proved to be a Type III carbonaceous chondrite, a rare variety of meteorite of which only a dozen or so other examples are known. It was the first such meteorite to occur in abundance and to be shared among many laboratories.

Allende is an aggregate of many types of particles, the most conspicuous of which are pink and white masses of high-melting-temperature minerals embedded in a black, low-temperature, carbonaceous matrix. The mineral suite in the light-colored inclusions includes several species that, according to calculations, should form among the highest temperature condensates in a cooling solar nebula. Thus, Allende contains a mixture of high- and low-temperature materials such as might have condensed early and late in a cooling nebula, or in different regions of a nebula, closer and farther from the sun. Either way, their random admixture is problematical.

The minerals of the light masses are enriched in calcium, aluminum, titanium, uranium, thorium, and the rare earth elements. Needless to say, interest in Allende redoubled after the discovery of the highly refractory nature of the lunar surface rocks, with their marked enrichment in the same elements. The chemical similarities led to a hypothesis, by Don L. Anderson of the California Institute of Technology, that the entire moon accreted as a huge mass of Allende-type refractory materials and later underwent internal melting and differentiation. He pictured the nearby earth as beginning earlier and growing faster, and sweeping up most of the heavy elements, such as iron and nickel, and all of the available volatiles. An alternative theory, proposed by the late Paul Gast of the Johnson Space Center,

was that the moon accreted inhomogeneously; that from the first its interior was rich in magnesium and iron, and only the outermost layer consisted of Allende-type refractory materials. He believed that the moon was originally cold and that melting began at the lunar surface and proceeded to deeper and deeper layers, where it produced magmas of differing compositions at different times. Remembering that many years ago Harold C. Urey had called the moon the cosmic Rosetta Stone, Gast referred to Allende as "the Rosetta Stone to the Rosetta Stone."

To many scientists, a disturbing aspect of Gast's hypothesis was that he pictured the high temperature refractory layer as the latest condensate on the moon rather than the earliest. A more widely accepted view is that the surface rocks of the moon result from large-scale melting and differentiation of an original basaltic parent rock. As a result of experimental work on lunar rock melts, David Walker of Harvard University has concluded that whether or not the entire moon accreted homogeneously, its outer radius was originally basaltic in composition to depths of hundreds of kilometers. In his model, early melting, triggered by accretional energy, of a surface layer perhaps 200 to 300 kilometers thick produced a light anorthositic crust about 50 kilometers thick overlying a denser fraction rich in ferromagnesian silicates. Many petrologists agree with this, and some argue that local pockets of KREEP-rich magma would be the final mobile residua of such a system.

From the pieces of evidence now available to us, we may reconstruct a lunar chronology:

4.6 billion years ago, the moon accreted to its present mass. Large-scale magmatic differentiation, accompanied by intense volcanism, produced the anorthositic crust within the first few hundred million years.

Once the moon's crustal materials had completely cooled, they were subjected to a spectacular bombardment of large bodies from space. Possibly the bombardment had been continuous throughout the earliest period of lunar history; possibly there was a cataclysmic bombardment of both the moon and the earth that began about 4.2 billion years ago and ended 3.9 billion years ago. Giant impacts produced large basins, such as Tranquillitatis, Serenetatis, Crisium, and Imbrium, in the rigid crust, and these stood open while their rims deformed and their floors rose isostatically. Impacts also resulted in shock melting and annealing that reset the atomic clocks of highlands rocks: 4.2 billion years ago, the light-matrix breccias of the Descartes site annealed; 4.05 billion years ago, the Genesis rock (an Apollo 15 anorthosite) annealed. 3.9 billion years ago, the Fra Mauro breccias were excavated from the Imbrium basin and projected outward over the lunar surface.

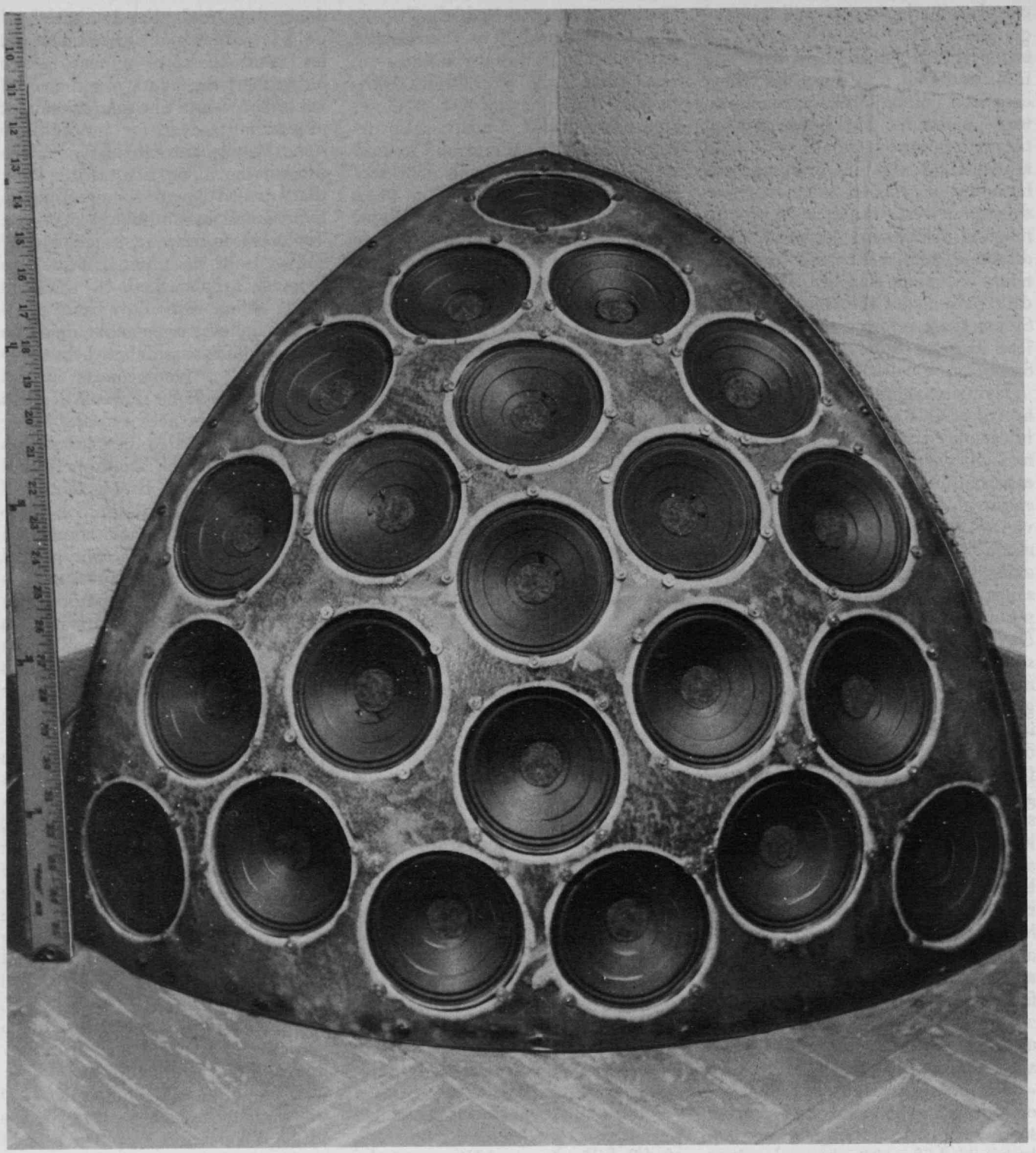
Many more millions of years passed before the partial remelting, due to long-lived radioactivity, of the dense silicate layer 300 kilometers deep began to produce dark-colored iron- and titanium-rich basalts that worked their way upward 3.8 to 3.1 billion years ago to fill some of the basins—mainly those on the moon's near side where the crust is thinnest—with a succession of lava flows.

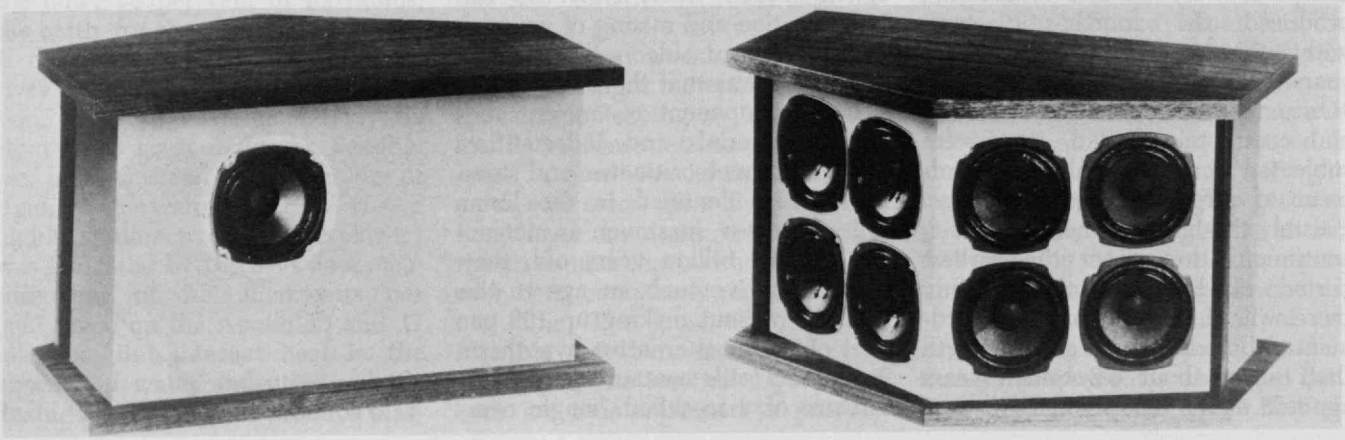
About 3.1 billion years ago, the moon became rigid to such depths that internal energy was no longer sufficient to cause surface modifications. The magnetic field was lost. Impacting projectiles (of decreasing size and flux rate) have cratered the surface and covered it with a fragmental regolith. 800 million years ago, an impact excavated the crater Copernicus and projected a ray of KREEP-rich glass across the Apollo 12 site. Other "recent" modifications include lunar landslides and the creation of tracks by boulders rolling down mountainsides.

Today, the moon, unshielded by an atmosphere, is the passive target of meteorites falling at cosmic velocities and of intense irradiation by the solar wind. It is covered with a regolith of its own debris which, as we noted earlier, yields a model age of 4.6 billion years. How can the pulverization and mixing of younger rocks create an older soil? An early suggestion was that the soils contain a large component of ancient meteoritic materials, and, indeed, tiny particles of meteoritic iron and stone have been identified in the lunar soils. However, inasmuch as meteorites are 4.6 billion years old, they could not give such an age to the regolith without making up 100 per cent of it. An alternative hypothesis is that the soils contain a small admixture of a so-called "magic component"—a rock that is highly enriched in radiogenic strontium and lead and therefore appears much older than the average soil age of 4.6 billion years. The matter remains as puzzling as ever.

The Apollo missions have shown us that the moon is a small planet that cooled to a state of inactivity more than 3 billion years ago. The earth, in contrast, is geologically active, with its internal heat continuously replenished by radioactivity. Mars, we now have reason to believe, is only beginning to heat up. What has delayed the process? Why is active volcanism limited to only one side of Mars? Will Mars ever become as active as the earth, bleeding volatiles to the surface that will create a thick atmosphere and standing bodies of water that may someday burgeon with life?

The Apollo and Mariner missions have demonstrated that every planetary body is unique. We have only begun to glimpse the questions we must ask in order to understand the solar system. The most valuable contributions of the Apollo program may have been most graphically shown by the photographs that were taken of the earth from outer space. The pictures impress upon us not only the beauty but the fragility and the isolation of the only viable home for mankind.





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Sound Recording and Reproduction

Part Two: Spatial and Temporal Dimensions

In 1964, we had created a speaker whose sound was subjectively indistinguishable from the sound of an ideal pulsating sphere, which we had simulated with the aid of a digital computer. But when music was played through this speaker, it exhibited many of the shrill, harsh sound characteristics that we had heard in conventional loudspeakers. It might at first appear that after eight years of research we were back where we began. That is, we had created a speaker with undesirable characteristics similar to those of speakers we had studied at the outset of our research.

In fact, we were at this time far ahead of our position in 1956, because we were now able to rule out certain factors as possible causes of the undesirable sound. The ideal pulsating sphere has, by definition, flat frequency response, perfect transient response, no distortion of any type, and omni-directional radiation. Since our creation, a loudspeaker consisting of an array of 22 radiators on a sphere, sounded identical to the simulated ideal sphere, we now knew that the undesirable sounds emerging from our speaker were not caused by frequency response, transient response, distortion, or by any deviations from omni-directional radiation that the speaker may have had. This realization was indeed surprising, since these four characteristics were thought to be the determinants of the sound quality of a loudspeaker. Yet we had now encountered a situation in which these characteristics were literally beyond question, but the undesirable nature of the sound remained. This marked the first time that we could conclusively state that attempting to improve the frequency response, transient response, distortion, or omni-directionality of radiation of our speaker design would offer no further audible benefits.

There was only one conclusion that could be drawn from the experiments that were completed in 1964: There must be other parameters important to hearing that had not yet been considered in speaker design. In 1965, we set out in search of these parameters.

Binaural Recording

We began by studying the method of sound recording and reproduction that enjoyed the reputation of being the most accurate: the so-called binaural method. Binaural recordings are made with two microphones placed in the ears of a dummy head which is positioned in an audience at a live performance. Reproduction of the performance is accomplished by playing back the signals recorded from the microphones in the dummy's left and right ears through headphones on a listener's left and right ears, respectively. In this manner, one attempts to duplicate at the listener's ears the acoustical signals that were present at the ears of the dummy recording head at the live performance.

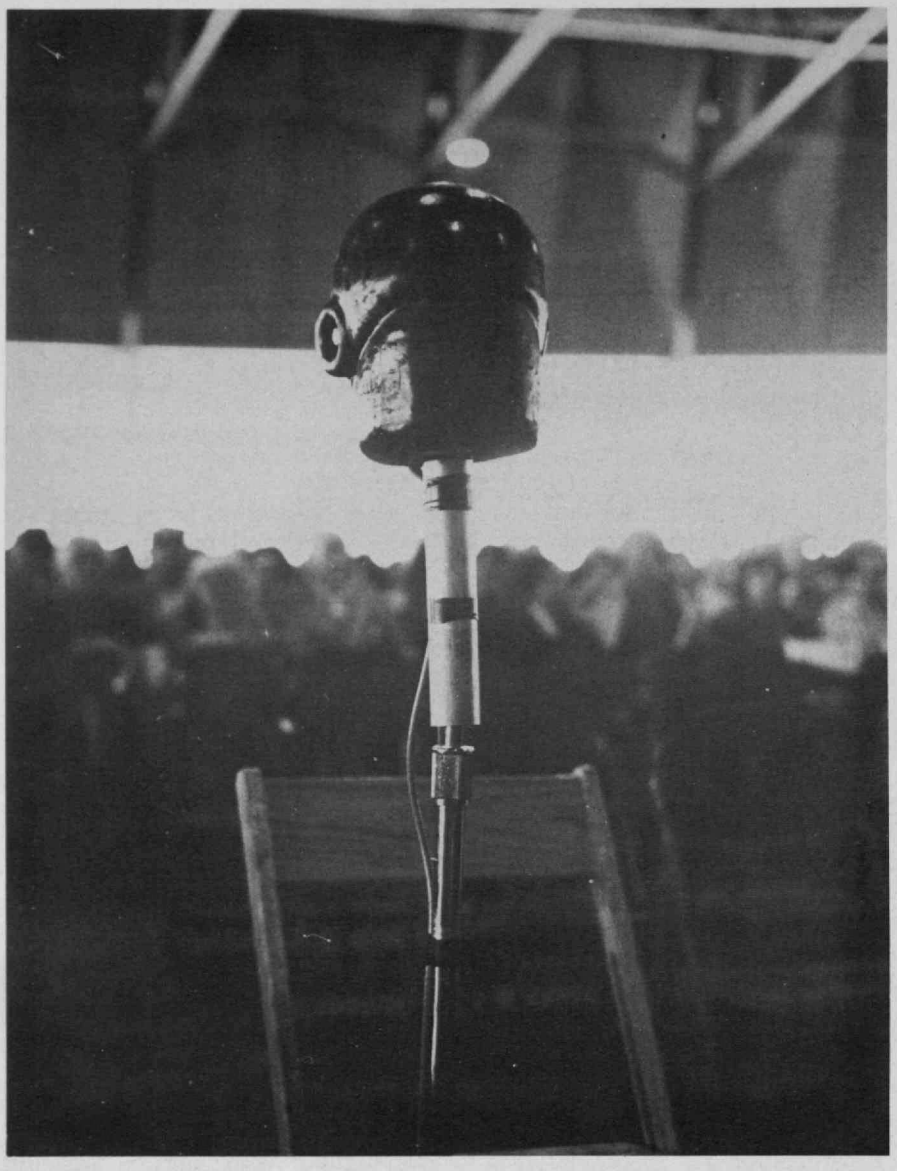
If you have ever heard good binaural recordings, you know that they are superior in many aspects to the sound you have heard from the best loudspeaker systems. The principle limitation—and it is an important one—of binaural recording and reproduction resides in the fact that signals at the ears of the listener made by binaural recordings do not change with motions of the head as signals do in the live performance. The failure of binaural reproduction to produce correctly changing signals with head motions is responsible for the often-observed sensation that the sound source is within the head of the listener rather than external to it.

Our first major experiments with binaural recording were performed at the Tanglewood Music Festival with the cooperation of the Boston Symphony Orchestra. The dummy recording head was seated fifth row center, and two track recordings were made of the signals from its left and right ear microphones. On playing our recordings, it was immediately apparent that the reproduced binaural signals did not exhibit the shrill, harsh sounds that were characteristic of the loudspeakers.

The most significant result of our experiment occurred when we added the left-ear and right-ear signals to make a monaural signal that we applied identically to each ear of the listener. When this monaural signal was played over the headphones, the shrill sounds were again

An ideal pulsating sphere is simulated by the eighth of a sphere shown at upper left. The eighth sphere in a corner of a room is equivalent to a full sphere floating in empty space, since ideal walls are to sound as ideal mirrors would be to light. Below left, front and rear views of a loudspeaker designed to radiate most of its sound backward, to reflect off the wall behind the speaker.

This is the second in a series of two articles on sound recording and reproduction by Professor Bose. Part One appeared in *Technology Review* for June, 1973, pages 19-25. Some of the research reported in this series was made possible in part by support extended the Massachusetts Institute of Technology, Research Laboratory of Electronics, by the Joint Services Electronics Programs under Contract No. DA 28-043-AMC-02536(E).



The dummy head used by the author and colleagues to make binaural recordings at the Boston Symphony Orchestra's Tanglewood Music Festival. Microphones in the dummy's left and right "ears" record the summation of sound pressures that would be present at the ears of a human concert-goer.

apparent. Many musicians and conductors of orchestras went through this binaural-monaural listening experience for us, and the results were always the same. In fact, when we switched the binaural signal into a monaural signal while one of the guest conductors at Tanglewood had our headphones on, he complained: "What did you do? All the evils of my HiFi have returned."

It is important to note that in this A-B experiment between binaural and monaural sound, the conventional parameters such as frequency response, transient response, and distortion of the recording and playback apparatus were unchanged between the binaural and monaural signals, since the monaural signal was formed by simply adding the two binaural channels together. This is exactly the type of experiment we wanted—an experiment in which the basic parameters that we had previously studied remained fixed and new parameters changed. Without yet knowing why it worked, we were able for the first time to suppress the harsh, shrill sounds without also losing desirable properties of the msuic. We then looked at the binaural system and interpreted the results of our experiment.

In a live performance, the sound waves radiated by musical instruments reflect from all surfaces of a concert hall and arrive at a listener's ears from all directions. Consider a sound wave arriving at the head from any given direction. Except in the case of sound sources exactly in front of or behind a listener, this wave arrives at one ear before it reaches the other, since the path lengths to the ears are unequal. In addition, depending upon the frequency range of the arriving wave, the spectrum of the signal that results from this wave will be different at the left ear and the right ear. High frequencies, for example, will be attenuated as they diffract around the head. Thus we see that, in general, there are time and spectral differences between the signals at the two ears for any given direction of the arriving sound waves.

In making a binaural recording, we measure the pressure at the plane of the pinna of each ear caused by the summation of all arriving waves, and attempt to reproduce this pressure at the corresponding ear of the listener through the use of earphones. Now imagine that we have added the left and the right channels together, then fed this signal to both headphones. The listener receives the same signal at each ear. This could be achieved without headphones by simply beaming the sound from a nearby loudspeaker directly toward the face of a listener.

Our experiment had shown that the monaural signals produced a sensation of shrill, screechy sounds typical of conventional loudspeakers, and that when the headphone signals were changed to the binaural signals, these undesirable effects disappeared. This strongly suggested that the undesirable effects produced by loudspeakers might be related to the distribution of angles at which the sound they produced arrived at the listener. In fact, it suggested that beaming sound waves at a listener might be the cause of the harsh, shrill and unnatural effects.

Motivated by the result of this binaural experiment, we shifted the focus of our research to the spatial aspects of the sound waves incident upon a listener. We conducted a series of experiments designed to determine the effect upon perception of varying the distribution of the angles of incidence of sound waves on a subject. One of our first experiments of this type involved placing five similar direct-radiating loudspeakers around a subject, and conducting the experiment so that the subject would first experience one loudspeaker directly in front of him, and then experience the sound from

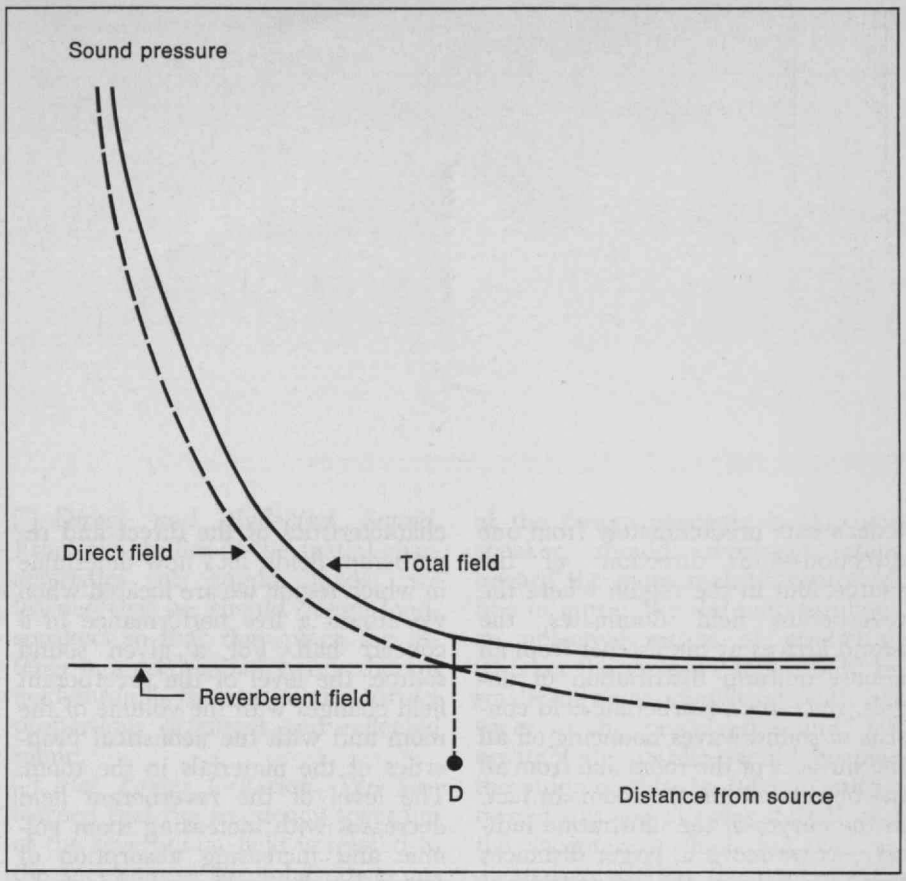
all five loudspeakers adjusted to create the same frequency spectrum at the position of the listener as the single loudspeaker had created. (This experiment must be carried out in a nearly anechoic environment.) We found that the undesirable harshness and shrillness observable from the single loudspeaker was significantly reduced when all the loudspeakers were simultaneously playing. This experiment and others indicated the importance of bringing the sound waves to the listener from a wide distribution of angles, which of course, was just the opposite of what had been practiced in loudspeaker design.

Direct and Reverberant Fields

The results of a number of spatial experiments encouraged us to study the characteristics of the sound waves incident upon the listener in concert halls. We soon discovered that a wealth of information already existed on this subject, resulting from decades of research in architectural acoustics. Although that research was directed primarily toward the design of large halls for live musical performances, it is not surprising that an understanding of the acoustics in a live performance can yield valuable information for the design of home music systems.

It is convenient to divide the sound incident on a listener in a concert hall into two categories: direct sound and reverberant sound. Direct sound is defined to be that component of sound that arrives at the listener's ears directly from the source—a musical instrument, for example—without any reflections: the sound that travels the straight path between the instrument and the listener. The reverberant sound is defined to be the sound that reaches the listener after one or more reflections from either the surfaces of the concert hall or objects within the hall. Clearly, by these definitions the direct sound and the reverberant sound encompass the totality of sound arriving at a listener's ears from the musical instrument.

Now consider, for convenience of analysis, the fields produced by an omni-directional source of sound suspended over the stage of a concert hall. The sound pressure of the direct field radiated from the source to the audience varies inversely with the distance between the source and a listener, as shown in the illustration on this page. This is the same situation that would prevail if the source and listener were located outside, and there were no way for sound to arrive at a listener via reflections. The sound pressure of the reverberant field, however, behaves very differently. Except for local maxima and minima at specific frequencies associated with the normal modes (resonances) of the hall, the sound pressure in the reverberant field is essentially uniform, independent of position in the room, as shown in the illustration.



The total sound field and its direct and reverberant components. Direct sound is that which travels the line from the source to the listener, without reflections. Reverberant sound is that which arrives at the listener after one or more reflections. At a certain distance D from the source, which depends on the nature of the room, the contributions of sound pressure from the two fields are equal. (But their sum is not double the pressure of either. Because the fields are uncorrelated, they are combined by taking the square root of the sum of their squares.)

The two curves reveal some interesting aspects of the total sound field and its direct and reverberant components. Notice that at a certain distance from the source (marked D in the illustration), the sound pressure of the direct field is equal to that of the reverberant field. At distances from the source shorter than D, the sound pressure of the direct field dominates and the sound pressure increases rapidly as we approach the source. At distances from the source greater than D, the reverberant field's sound pressure dominates and, in fact, the total sound pressure becomes virtually independent of distance from the source. You have experienced in your home a consequence of the shape of this curve of total sound pressure versus distance if you have ever listened to a radio, first with your ear very close to the loudspeaker and then while walking away from the speaker across the room. When you are very close to the loudspeaker—within a foot or so—it is quite loud; that loudness decreases as you walk away, but depending upon the size of your room, after you are three to six feet away from the speaker, the volume level remains about constant as you move across the room.

The spatial natures of the sound fields in the regions closer to or farther away from the source than D are very different. In the region where the direct field dominates, the sound obviously arrives at the lis-

tener's ears predominately from one direction—the direction of the source. But in the region where the reverberant field dominates, the sound arrives at the listener from an almost uniform distribution of angles, since the reverberant field consists of sound waves bouncing off all the surfaces of the room and from all the objects within the room. In fact, as the curves of the illustration indicate, as we move to larger distances from the source, the magnitude of the direct field sound pressure becomes negligibly small compared to that of the reverberant field. At these larger distances, the sound pressure of the waves incident upon a listener would be at essentially the same level for all angles—including the angle corresponding to the direction from the source, since the magnitude of the direct field is so small compared to that of the reverberant field.

Another important difference between the fields in the two regions is in their frequency spectra. The frequency spectrum close to a source—that is, in the region where the direct field dominates—is that which the source radiates along the axis from it to the measuring point. In the reverberant field, however, the frequency spectrum is related to the total acoustic power that the source radiates in all directions, since it is that total power which is the source of the reverberant field. (Clearly, the absorption characteristics of the room enter into the spectrum of the reverberant field, but the point we wish to make here is that the total power radiated from the source, rather than the radiation along any particular axis, is what creates the spectrum of the reverberant field).

Having examined some of the basic characteristics of the direct and reverberant fields, let's now determine in which region we are located when we attend a live performance in a concert hall. For a given sound source, the level of the reverberant field changes with the volume of the room and with the acoustical properties of the materials in the room. The level of the reverberant field decreases with increasing room volume and increasing absorption of sound by the walls and objects in the room; and the distance from the source at which the sound pressures of the direct and reverberant fields are equal becomes larger. For omnidirectional sources, this distance varies from a few feet in small rooms to 19 feet in Boston Symphony Hall. For directional sources, the distances are greater, depending upon the degree of directionality of the source. What is clear is that virtually all of the audience in a concert hall is seated in the region where the reverberant field is dominant. Therefore the spatial and spectral aspects of the sound incident upon the listener in the audience are those we have described for that region.

The physical characteristics of the sound field might at first seem to contradict human perceptual abilities. When we consider the result that the reverberant field is dominant in the audience and that it arrives with virtually equal intensity from all directions, we are tempted to conclude that this situation would preclude our ability to locate the direction of musical instruments, or even the direction of the stage upon which the instruments are playing. Of course, this is not the case. While an instrument plays, it is continually emitting new acoustical signals. Each of these signals reaches our ears first by the shortest path from the instrument to us and then, tens of milliseconds later, arrives repeatedly via reflections as part of the reverberant field. It is well established that we make use of the first arriving wave—that is, the direct field—for detecting direction and that we can localize the source via this first wave even though its sound pressure is far below that of the reverberant field. This localization ability is similar to that involved in the so-called cocktail party effect: in the midst of a gathering of people, we can, if we so choose, localize and focus on one conversation in the presence of an ambient sound level that is much higher.

The reverberant field, while contributing nothing to our ability to localize, plays a very important role in our perception of the timbre of music. Since the reverberant field is dominant in the concert hall, it determines the ratios of harmonics to fundamentals, and therefore the timbre of musical instruments. (Angles of incidence and temporal effects also strongly influence our perception of the timbre of instruments, but these, too, are associated with the reverberant rather than the direct field.)

Loudspeaker Design

Our original motivation to study the sound field in a concert hall had come from binaural recording and other experiments that indicated that many of the harsh and shrill sounds encountered in loudspeaker music reproduction may be due to the fact that loudspeakers have been designed to beam the sound directly at the listener, as opposed to delivering it to the listener from a wide distribution of incident angles. Our study of the concert hall had re-

vealed that sound does in fact arrive at the listener's head with virtually uniform distribution of angles. Thus, our object should be to design a speaker that radiates only a small portion of its energy directly toward the listener and grazes the larger portion of its radiation off the walls of the listening room to create spatial patterns in that room comparable to the spatial patterns one receives in the audience of a live performance. Experimenting with this concept, we found that excellent results were obtained by employing about ten per cent direct radiation toward the listener and about ninety per cent of the radiation at 30° angles toward the wall behind the loudspeaker. In terms of a practical design, we accomplished this by a loudspeaker (shown on page 24) with a single driver mounted on a front panel and four similar drivers mounted on each of two rear panels that array those drivers at a 30° angle to the rear wall, which now functions like the stage wall behind the instruments in a live performance. Since we are much closer to a loudspeaker than we are to the instruments in a live performance, our loudspeaker design called for a large ratio of reflected to direct sound. The small amount of direct sound is all that is required for localization.

To summarize what we had learned from our research:

☐ *Multiplicity of Full Range Speakers.* From the spark experiments described in the first part of this article (which appeared in *Technology Review* for June), we learned that it is possible to produce music without audible coloration from distortion, resonances or transient response irregularities by the use of a multiplicity of full range speakers.

☐ *Direct and Reflected Sound.* From our studies of the spatial characteristics of sound fields, we learned that we should design loudspeakers so that they place the listener in a predominately reverberant field through the use of the correct proportions of direct and reflected sound.

☐ *Flat Power Criterion.* We also learned that the frequency spectrum of the reverberant field is related to the spectrum of the total power radiated by the source or loudspeaker. Therefore, if we are to achieve the same balance of frequencies in our listening room as we experienced in the live performance, the loudspeaker should be designed to a flat power criterion rather than the conventional flat-frequency-response-on-an-axis criterion.

☐ *Equalization.* Loudspeakers do not inherently meet the criterion of flat power response, since it has been traditional to design them to approach flat frequency response. However, with proper equalization, we can adjust the frequency balance of the electrical signals entering the loudspeaker so that the sound waves that emerge will satisfy the flat power criterion. This can be accomplished with the aid of an electronic frequency equalization network.

Having incorporated our research findings into the design of a loudspeaker system, we were again confronted with the basic problem we discussed in Part One: there exists no objective measure for the space of sounds, and therefore there is no objective way of telling whether the performance of one design is superior to that of another—let alone whether a design is optimum. The only thing we could state was that, based upon our research in physical acoustics and psychoacoustics, each of the design concepts in the new speaker should represent steps toward the more realistic reproduction of music. We did not even have an objective means of predicting whether the steps we took would be small or quite significant with respect to the perceived sound. Ultimately the public would become the judge of this. In 1968, manufacture of this speaker was started, and the acceptance which followed indicated to us that the concepts involved produced changes that people regard as significant improvements.

Looking Ahead:
Sound Reproduction . . .

Where do we go from here? Have we optimized all the parameters for music reproduction in the home, or can we expect to do a significantly better job in the future? We might feel compelled to say that of course we can do better in the future, because such is the nature of progress. However, with respect to specific tasks, research can and does bring the state of affairs to a point where further work toward that specific task results in diminishing returns. For example, it is safe to say that electronics technology has brought the state of amplifier design to the point where well-designed amplifiers introduce no audible coloration into the signals they amplify. This situation will not be improved upon in the future by any technique. But progress may well bring amplifiers of smaller dimensions, lighter weight, less power consumption, and possibly less cost.

Our answer to the question, "Can we expect better home music reproduction in the future?" is a resounding yes. We think that the next five to ten years can bring dramatically

superior music reproduction into the home, but it may come through different avenues than one might at first expect.

In looking at what has been accomplished as well as what remains, it is convenient as well as accurate to organize the problems into three groups:

☐ *Spectral Problems*, under which we shall include, by definition, the topics of frequency response, distortion, and transient response.

☐ *Spatial Problems*: the distribution of angles of incidence of sound upon the listener. This is not to be confused with the localization of sound by the listener, which can be affected by the balance of stereo channels in the recording process. Here we are simply involved in geometrical considerations relating the loudspeakers, the room, and the listener.

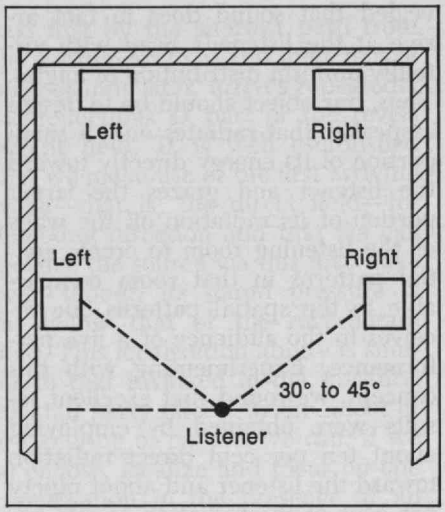
☐ *Temporal Problems*: those concerning the environmental characteristics that enable us to distinguish the acoustics of a large hall from those of a small room. We make this distinction using primarily characteristics of the music signals that are best described in the time domain, as we shall see.

We will first consider the problems of reproduction of sound. The results of the experiment that simulated the ideal pulsating sphere, described in Part One, are sufficient to assure us that the spectral problems of loudspeaker design are well in hand. That experiment showed us that through the techniques of multiplicity of full range speakers and equalization we can reduce the problems in the spectral category to a point below the threshold of audibility. In practical applications, one can expect small continued improvement due to minimizing the tolerances in production units, but at the research level the spectral problems can be considered solved.

There is room for significant improvement in the spatial characteristics of home music systems. After all, we are quite lucky to achieve any decent results when we attempt to reproduce the sound of a 70-piece orchestra in a large concert hall through two loudspeakers in our living room. Yet we do not expect that we can make large improvements over the spatial characteristics of a loudspeaker of the type developed in our research. The kind of spatial improvement needed might be produced by an enormous radiating surface which covered the front wall of a room and overlapped around the side walls to produce the sensation of sound from a 50-foot stage. This impractical transducer can be approximated (the illustration above) with satisfactory results by a second pair of speakers against the side walls of the listening room positioned 30 to 45 degrees ahead of the listener. Thus we expect the major improvements in the spatial aspects of music reproduction to come from the use of additional speakers rather than from improved design of the individual speakers.

The temporal problems offer the greatest opportunity for improvement of music reproduction. As we shall see, the temporal parameters are not under the control of the speaker designer. Rather, they can be affected through additional channels of information and signal processing yet to be developed.

To understand the temporal parameters, consider the following experiment. Imagine that you are blindfolded and taken into a concert hall and into a much smaller room. In each case, you are asked to speak or



A way to simulate the sensation of sound emanating from a large stage, without having a sound-radiating surface that wraps around the living room walls. Each stereo channel drives two speakers.

to listen to the playing of a live instrument. You would easily be able to tell which was the concert hall and which was the small room. It is sometimes said that the distinction is made on the basis of the longer reverberation time of the concert hall. While you would certainly perceive this, it is not the dominant factor that enables you to judge the size of a room. Tiled shower rooms with dimensions of only 15 to 20 feet on a side will often have reverberation times significantly greater than the reverberation times of concert halls, yet you will be aware that you are in a small room when you stand blindfolded in the shower room. It turns out that the times *between* reflections of sound are more significant parameters for sensing the size of a room. And the mean time between reflections in a large concert hall is an order of magnitude greater than that in an average living room.

This points out a significant problem for home music systems attempting to approximate a concert hall performance. All the sounds emitted from the speakers in the listening room bounce around the room with a mean time between reflections typically as small as 7 to 12 milliseconds, depending upon the size of the room. Thus, we cannot expect any pair of stereo speakers located in a living room to provide the temporal sensations that are so important in a live performance.

To a small extent, some sensation of reverberation can be introduced into recordings. However, this technique is very limited in its effect, for when the reverberated sound is emitted from the same location as the original signal, and when it bounces around a small room together with that signal, the result tends to be loss of definition and otherwise unpleasant effects long before the amount of added reverberation in the recording becomes comparable to what one would experience in the live performance. To successfully give the impression of a large hall to a listener in a relatively small room, it seems that it will be necessary to employ additional speakers located toward the rear of the listening room and to drive those speakers with signals that will give the listener some of the sensations that he gets from the sound waves that bounce off the side and rear walls of the concert hall. The signals that are fed to these additional speakers will be different from those fed to the two front stereo channels. Each different signal must be amplified by an additional channel of the music reproduction system.

It does not follow that the proper signals to apply to these additional channels would be recordings made further back in the concert hall. Such recordings would experience the reverberation of the hall as well as that of the listening room to yield a very undesirable result.

Fundamentally, it appears that all the information necessary to derive the signals for the additional channels resides in current stereo recordings. To achieve our desired result, we want to record signals close to the orchestra, as done in many current stereo recording techniques, and process these signals in such a way that when they are played back over additional channels in a small room, they will produce some of the sensation that one would experience in the larger concert hall. It is not yet certain that this can be achieved, but based upon some research that we have already conducted, the prognosis is good. At this point in time, the signal processing would require more equipment in the home than is presently feasible. However, with the rapid development of integrated circuits, it would not be surprising if signal processors for deriving additional channels were available in a few years in the size and price range of current receivers.

One system of adding additional channels for home music reproduction is known commercially as quadraphonic sound. While the general principle of additional channels has excellent prospects, the present practices leave much to be desired. There are various systems using so-called matrixing methods available today, which attempt to combine four channels into two for broadcast or recording and recover them at the receiver, and which also synthesize four channels from the two channels of an ordinary stereo broadcast or recording. The problem of compressing four channels of information into two without increasing the bandwidth or dynamic range of the existing channels is analogous to the problems faced 25 years ago when the additional information required for color television was successfully included in the bandwidth previously used for only black-and-white. The difference is that the intensity and the competence of the research applied to solving the problems in color television was far greater than that which has been applied in the audio industry to the problem of quadraphonic sound. It is safe to say that none of the existing matrix methods are well founded from a technical point of view, and that their performance is consistent with the level of their technical development. Quadraphonics as presently practiced is a striking example of the danger in allowing marketing departments to establish standards of technology based upon the very first efforts of the engineers. Should the pressures of industry result in the Federal Communications Commission accepting one of the present matrixing methods, the great potential benefits that reside in multiple-channel music systems might never be realized.

On the brighter side, I suppose that one can rationalize that the existing systems of quadraphonics have a role if whatever they produce is sufficient in the judgment of the consumer to justify a purchase. In this connection, we must always keep an open mind with respect to the objectives of any medium of entertainment. While most of our work has been devoted to more accurately reproducing the sensations of a live musical performance, there are certainly valid pursuits which simply create interesting effects with the hope that artists will learn to use

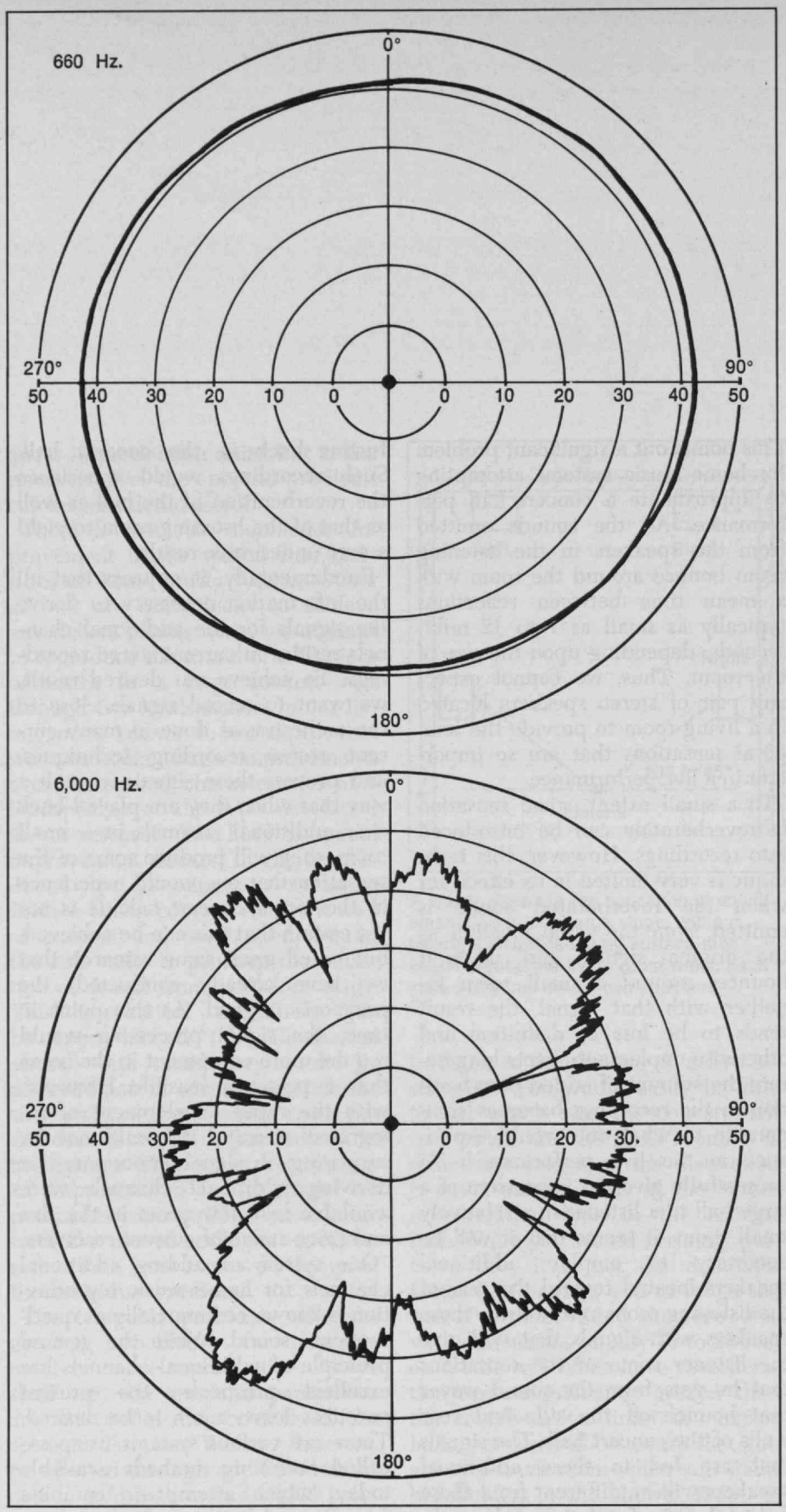
these new systems much as they would learn to use new instruments.

. . . And Recording

In looking at the future of home music systems we must also consider the techniques of recording. The problems fall into two categories: equipment limitations and limitations of the acoustic field in the recording environment.

With respect to equipment limitations, the most salient problem is the dynamic range problem, which manifests itself as noise level that is obvious during quiet passages of music. The smallest amount of audible hiss on a recording, for example, detracts markedly from the realism of the reproduction. In research situations, which are fewer tape copies removed from the original performance than are commercial recordings, and where special measures can be taken for the sake of experiment, it is possible to make recordings that are relatively noise-free. The comparison of these recordings with most commercial recordings is rather striking: The elimination of the noise has an effect on the listener greater than would be expected considering the small magnitude of noise present in commercial recordings. Progress is being made. The noise level of commercial recordings is being reduced. The last few years have seen a great improvement in magnetic recording tape as well as the development of two effective systems for noise compression during recording. If progress in this direction continues, we may witness the elimination of the problem in this decade.

The problems in recording that are associated with acoustic fields are more formidable and will require significant research. Let's look briefly at one of these problems: the problem of recording a solo violin. As is the case with many musical instruments, the polar pattern (a plot of sound pressure level versus direction of radiation) of the acoustic radiation from the violin becomes very complex as the wavelength of the sound becomes small compared to the size of the instrument. Polar patterns for 660 Hz (a violin's open E-string) and 6,000 Hz (the ninth harmonic of open E) are shown in the illustration at the right. Recall that the frequency spectrum of the reverberant field is related to the frequency spectrum of the total



The radiation patterns of a violin's open E string (660 Hz; top pattern) and the ninth harmonic of open E (6,000 Hz; bottom pattern). Six dB difference between two measurements corresponds to a doubling of sound pressure. The radiation pattern of the violin becomes complex as the wavelength of the radiation shrinks toward the dimensions of the instrument. (Source: "Effects of Directional Radiation from Violins upon their Recorded Sound," by Victor Nedzelnitsky. Undergraduate thesis, Electrical Engineering, M.I.T., 1966.)

power radiated by the acoustical source rather than to the balance of frequencies on any one axis of radiation. In order to determine the total power radiated by the violin at 6,000 Hz, it would be necessary to integrate over a series of polar patterns of the type shown in the illustration, each representing the radiation in one plane, until we had spanned a spherical surface with the violin at its center.

If we were to place a recording microphone close enough to the violin to be predominantly in the direct field, we see from the polar plot that the sound pressure level picked up by the microphone could easily vary by 20 dB depending upon the position of the microphone. For example, if the microphone were located in a position corresponding to 90° on the 6,000 Hz plot, the sound pressure level would be more than 20 dB greater than the sound pressure level that the microphone would pick up if it were located at an angle of 70°. At other frequencies, the situation is very different. For example, we can see from the polar pattern for 660 Hz that the 70° and 90° angles yield essentially the same sound pressure. It is plain that we cannot expect to find any angle for the microphone placement that will at every frequency yield a signal proportional to the total power radiated at that frequency by the violin. In other words, when the microphone is placed close enough to the violin to be predominantly in the direct field, it does not pick up the spectral balance of the reverberant field that we experience in the concert hall. Instead, it picks up a balance of frequencies proportional to the radii of the polar patterns at each of the different frequencies for the angle of the microphone position.

The solution to this problem is not so simple as removing the microphone to the reverberant field, because in recording there, we encounter all the normal modes of the recording environment, which, when reproduced through a second set of normal modes—those of the listening room—produce a barrel-like sound that is totally unacceptable.

The recording engineer is really caught between two undesirable limits. If he places the microphone close to the performer in the direct field, he picks up a spectral balance that is critically dependent upon microphone position, and that is not the desired balance of the reverberant field. But if, seeking to avoid this problem, he moves the microphone farther away and into the reverberant field, he encounters the normal mode problem.

It is interesting to note that, without realizing the nature of the technology involved, most recording engineers usually place their microphones at a distance (when normalized for microphone directionality characteristics) from the performer that is close to the distance at which the levels of the direct and reverberant fields are equal. In this way, the spectrum of the recording is influenced to some extent by the spectrum of the reverberant field without too heavy an influence of the normal modes.

This represents a good compromise between bad alternatives. We would like to be able to record in such a way that we capture the spectrum of the total radiated acoustic power from the performer unaltered by the normal modes of the recording environment. We are presently studying the possibilities for designing acoustical environments that lead in this direction. It would not surprise us to find that recordings of the future will be made in unusually shaped environments that act as "acoustic lenses" to focus the radiated power, and that these recordings will then be fed into computers that will process the signals so that when they are played back in homes they will produce a reasonable sensation of the large environment of a live performance.

In summary of our predictions of the future:

☐ The state of the art in HiFi components is such that, with the exception of dynamic range in recordings, we do not expect major improvements in performance from individual components. The evolution of components will be in reliability, size, weight, and cost.

☐ We expect dramatic improvements in the overall performance of home music systems, but we think they will come through systems engineering rather than through component development. By systems engineering, we mean engineering that considers the entire system from recording to playback, develops appropriate signal processing techniques, and uses existing components, or modified versions of them, as building blocks to synthesize new and strikingly superior music systems. This is exactly the course the electronics industry has followed. First the individual circuit elements were developed, then circuits were synthesized, and now systems engineering has combined these circuit building blocks to create complete high performance systems in every discipline from industrial process control to guidance systems for space vehicles. The HiFi industry is now ready for systems engineering.

My profession has habituated me to making homework assignments at the conclusion of presentations. This assignment is lighter than this presentation has been, and it is disgustingly appropriate: Read Hans Christian Anderson's "The Emperor's New Clothes," and substitute "HiFi" for "clothes" throughout. At the conclusion of this assignment you will have a good picture of much of the "development" and "evaluation" efforts that have characterized the HiFi field. But with a little bit of luck, we may be at a turning point which will see more serious research and consequent progress. At the risk of being proved wrong, let me conclude with a prediction that I must admit is entwined with hope. If research bears the fruits that I believe are possible, the home music system of the future will bring to many people an appreciation of music unimagined today.

The blob is an amoeba, superimposed on a memory chip announced by I.B.M. in February, and now in test production. The amoeba covers 40 "transistor cells," each of which, .00184 inches square, can store a binary 0 or 1: a "bit." The entire memory chip, a quarter of an inch square, can store 8,192 bits. Photo courtesy I.B.M.

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The Future of Computers

A survey of a rapidly changing field. Briefly, computers will be more powerful, cheaper, and easier to use.

During the 1960s, after a decade of gestation, the computer captured the public's imagination and attention. It was in this period that many of today's engineers and managers first became exposed to, and knowledgable about, computer systems. Advances have continued into the '70s, but the scope of the industry has become so broad that it is difficult for anyone not deeply involved in the field to have followed the more recent changes. This paper will highlight many of these developments and forecast their future impacts. Due to the scope of the subject and the brevity of this article, it will be possible only to touch lightly on each matter, but it is hoped that this article will help to put developments into perspective and serve as an initial reference point for readers interested in pursuing a particular topic.

We will divide our subject into three categories: technological cost/performance breakthroughs in computer manufacturing; the evolution of computer system architecture, for both hardware (the computing apparatus) and software (computer programming); and major steps toward meeting the requirements and capabilities of the user.

Technological Cost/Performance Breakthroughs

The hardware in a conventional computer system consists of an ensemble of components, including the *processor*, which performs computation; *main storage*, which holds the data and instructions used by the processor; and *input/output devices*, which include input-only devices such as punched-card readers, output-only devices such as printers, and input-and-output devices (also called *secondary storage devices*) such as magnetic tape units.

Many technological developments in computer system hardware will have significant effects on cost, performance, size, and reliability. Since there is extensive activity in computer technology, we will single out only major trends. One warning is necessary: *Costs* in the computer industry are highly volatile, difficult to determine, and strongly influenced by production volume. *Prices*, however, are usually determined by market conditions and often have little technical significance.

☐ **Microprocessors** can be defined as small computer processors that consist of one or a few semiconductor integrated circuits, manufactured by techniques of large-scale integration (L.S.I.). Integrated circuits are based upon conventional semiconductor transistor principles, but by using special materials and production (for example, ion implantation and photographic masking), it is possible to manufacture and interconnect hundreds or thousands of transistors on a single silicon chip. Such a processor's size is measured in inches. A simple form of this technology has sparked the recent growth of hand-held electronic calculators.

There are many differences among the various microprocessors. One of the earliest and simplest, the Intel MCS-4, is a four-bit parallel processor, where a bit (short for *b*inary dig*it*) is a unit of information: a choice between a 0 or a 1 in the binary number system. A four-bit parallel processor performs operations on four bits simultaneously, rather than one at a time. The MCS-4 can execute 45 different instructions with a 10.8 microsecond instruction cycle—that is, it can execute almost 100,000 instructions per second. By comparison, one conventional computer, IBM's 370/145, has a 16-bit parallel processor, can execute over 100 different instructions, and has an instruction cycle of a microsecond or below (about 1,000,000 instructions per second).

The microprocessor does have important advantages in cost and size. The heart of the MCS-4, the 4004 Control and Arithmetic Unit, sells for $30 each in 100-unit lots. The entire 4-chip MCS-4 system sells for $48 each in 100-unit lots.

There are no serious technical impediments to the development of microprocessors, since they are typically based upon standard metal-oxide-silicon large-scale-integration (M.O.S./L.S.I.) technology. The present problems are largely customer education and acceptance. The manufacturing cost is very sensitive to production quantity; it costs only slightly more to manufacture 10,000 microprocessors than it would to produce 1,000. The joke that the only raw material required is a few shovels of beach sand, though not technically true, indicates the situation. (The table on the next page illustrates the sensitivity of L.S.I. cost to production quantity for processor and memory circuits.) The marketing problem becomes quite apparent when one recalls that after 25 years there are still less than 200,000 con-

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Circuit Type	Complexity	Manufacturing cost per chip in production quantities of: 10	100	10,000
Logic circuits (processor)	2,000 (equivalent transistors)	$260.00	$30.00	$ 5.20
Random-access circuits (memory)	16,000 (bits per chip)	$422.40	$57.60	$20.48

The sensitivity to production volume of processor and memory circuits manufactured by large-scale integration. The need to develop a sizeable market to realize substantial savings in manufacturing costs is obvious. Source: G. A. Saxton & Co., Inc., "Future Computer Systems," by L. Duane Kirkpatrick, *Industry Note No. 33,* March 26, 1973.

ventional computers in the world. For economic production, it is desirable to sell that many processors *per year.*

In spite of these problems, the list of participants in the microprocessor sweepstakes reads like a Who's Who of the semiconductor industry. Companies enter and leave and re-enter this list continually.

The immediate need is to develop uses for microprocessors.

"Non-Computer" applications, by which we mean integrating the microprocessor into a larger system, have been achieved for years with minicomputers (computers selling for $10,000 or less), but will be accelerated by the low-cost microprocessor. The possibilities are limitless. Frequently mentioned applications include machine-tool control, telephone switching, medical electronics, automotive controls, and digital watches. In addition, there are many applications for which a low-performance, inexpensive microprocessor is quite adequate. Compared with human skills, a "slow" 100,000-arithmetic-operations-per-second "personalized" computer is quite impressive. For example, the Hewlett-Packard HP-35 Pocket Calculator (battery powered) can perform logarithmic and trigonometric operations with about 10-digit accuracy in less than a second. The newer HP-80 Business Calculator can perform interest rate, averaging, and other calculations at similar speeds. Such calculators are faster and easier, and are usually more accurate, than slide rules or table-interpolation techniques. Microprocessors will also have their impact upon sophisticated remote computer terminals. In fact, much of the current microprocessor activity is jointly sponsored by terminal manufacturers and the semiconductor companies. Finally, the larger and more powerful microprocessors could pose a threat to the current minicomputer market. These microprocessors could evolve into small stand-alone business computers (accounts receivable, payroll, etc.)

Medium-scale computers, such as the IBM 370/135, 370/145, and 370/155, represent the major segment of the current computer market. A single microprocessor and even its slightly more expensive and powerful cousin, the minicomputer, does not have the processing power or input-output flexibility to compete with the medium-scale computer. On the other hand, medium- and large-scale computers are becoming more and more decentralized. Separate processors are being used to serve different functions. In addition to the central processors that execute instructions, there are input/output processors (often called channels) and special input/output-device processors (often called control units). As the cost of microprocessors drops and their performance improves, one becomes tempted to use these general-purpose units in place of the many different specialized processors in a medium-scale computer. This trend is already apparent in the recent introduction of the Burroughs BI700 system, based upon the Burroughs "D" machine multiprocessor military computer, and the IBM System/370 Models 115 and 125, which use several separate microprocessors internally.

There are many factors likely to accelerate this trend toward multiprocessor configurations. One intriguing argument is based upon the impact of the rapidly changing state of the art on the development cycle—the time from product conception to full production. Typically, the development cycle is about five years for medium-scale computers, but the simpler minicomputer often breezes through in two years, occasionally in less than 12 months. Many important decisions must be made early in the design cycle, involving such matters as system performance, circuit types, memory modules, and packaging approaches. The designer of the medium-scale computer must make these decisions four to five years before production. If he chooses to use existing technology, the final product will be several years behind the state of the art. If he extrapolates and projects the availability of future technology, he is likely to make some bad guesses that will result in last-minute redesign and inefficiencies. By building medium-scale computers out of multiple general-purpose microprocessors, the final design may be slightly "less optimal" than one using specialized processors, but that is more than offset by the increased ability to use more current manufacturing techniques, as well as the advantages of much larger quantity mass production, which dramatically reduce the cost of such a system. The miniaturized size of the processors will allow considerable reductions in cabinetry, power supplies, etc. Modular construction will have its impact on other costly areas, such as servicing. Processors might even become disposable.

A long-range forecast for microprocessors is difficult. The present sales prices may be somewhat artificial, since few of the manufacturers are in full-scale production. There are improvements possible in all directions. Eight-bit and sixteen-bit parallel microprocessors have been developed. There has been at least one prediction of microprocessors costing as little as $1 within 25 years that will have a processing rate up to 10,000,000 instructions per second. But such a long-range estimate is strictly conjecture.

The dramatic reduction in microprocessor costs must be carefully considered. The current manufacturing costs of a computer system

represents about 25 per cent of the sales price (marketing, software development, research, and profit account for the rest). The processor may represent only a third of the system, the other two-thirds being memory and input/output devices. Furthermore, the processor's electronics, excluding power supplies, etc., may represent less than a third of the processor's total cost. Thus, the advances in microprocessors affect less than three per cent of a medium-sized computer system's sales price! Thus, while we can expect tremendous advances in processor technology, the impact upon the user will be minimal unless there are also dramatic changes in other areas.

☐ **Main Storage** (also called main memory or, historically, "core memory") typically represents about a third of a computer system's cost. The breakthroughs in this area—both attained and predicted—have received considerable attention.

Semiconductor technology can produce circuitry capable of "storing" binary 0's and 1's. Due to the very high volumes, simplicity of structure, and modularity of these memory devices, all of the semiconductor technology benefits to processors also apply to memory. Most of the computers currently being manufactured use semiconductor main storage instead of the traditional magnetic ferrite core memory.

The semiconductor memory market is extremely competitive in both price and technology. The Intel 1103, a 1,024-bit M.O.S. semiconductor memory circuit, has become an industry standard and versions are manufactured by several companies. Due to economies of scale and a very steep "learning curve," the cost of such circuits has dropped by a factor of ten in a little over one year. With the eventual commercial maturity of larger semiconductor memory chips (4,096 bits and above), the cost per bit of memory is likely to drop by another factor of ten in the next few years. (The photograph on page 34 shows an 8,192-bit memory chip now in test production.)

We can expect future computers that have larger capacities, smaller sizes, and less costly main storages. As an indication of this trend, the minimum size IBM 370/135 (at 98,304 bytes of main storage; a byte is eight bits) is larger than the maximum size IBM 360/30 (at 65,536 bytes), its predecessor.

System Component	In 1970 Cost	In 1970 Percentage of total	In the late 1970s Cost	In the late 1970s Percentage of total
Main memory (1,000,000 bytes)	$120,000	35	$ 2,400	4
Special memories	40,000	11	2,000	3
Processor logic circuits	50,000	15	2,600	4
Special circuits	20,000	6	8,000	12
Processor subtotal		32		19
Packaging	30,000	9	10,000	15
Power and cooling	30,000	9	15,000	23
Other	50,000	15	25,000	39
Miscellaneous subtotal		33		77
	$340,000		$65,000	

The costs—recent and projected for the end of this decade—of the component parts of a large computer's mainframe (its processor and its main memory). Source: "Future Computer Systems," G. A. Saxton & Co., Inc.

Main storage used to be the most expensive component of a computing system. Based on the estimates of the table on this page, it will soon be possible to obtain ten times the storage capacity at one-fifth the cost. Many of the current ploys aimed at conserving main storages (program overlays, input/output buffering and handling, for example) will be unnecessary. This will result in easier program development and simpler, yet more powerful, operating systems.

☐ **Intermediate and Secondary Storage.** The use of high-performance, direct-access secondary storage (such as magnetic disk units) was accelerated by the IBM System/360, introduced in 1964. By now, it is an area of considerable competitive pressure. The sales volume of the basic IBM 3330 Disk Storage Unit alone is expected to reach over 1 billion dollars. A single 3330 module, storing 100,000,000 bytes, has more than ten times the capacity and double the access speed of its ancestor, the IBM 2311, introduced less than ten years ago.

Current secondary storage devices are largely based upon rotating magnetic media (for example, magnetic disks, magnetic drums, magnetic tape strips, and so on). This technology can probably be pushed another factor of ten in capacity and a factor of two in speed in the next five years. Beyond that point, there are at least three limitations to the electromechanical approach. We are rapidly approaching physical limitations in magnetic media recording capacity and speed. Due to the need for costly mechanical motors, the cost per bit of storage may be decreased by increasing capacity, but the unit cost continues to increase. Finally, the mechanical approach has inherent speed and reliability limitations.

There are numerous technologies being pursued that lead to storage devices falling between the traditional high-cost, high-performance main storage and the lower-cost, low-performance electromechanical secondary storage. All of these intermediate storage approaches have been successfully demonstrated in the laboratory and, in some cases, in limited production. The most successful should be in full production within five years. These technologies include:

M.O.S./L.S.I. Shift Registers. The technology is similar to that of M.O.S./L.S.I. main storage modules, but rather than direct "referencing" of each storage location, the data bits are circulated (shifted) along a register. Data is usually read or written only at the ends of the shift register, analogously to the use

of read/write heads of a conventional rotating electromechanical storage device. It is possible to produce M.O.S./L.S.I. shift registers with higher capacities and lower prices than those of comparable direct-access M.O.S./L.S.I. main storage.

Charge-Transfer Devices, specifically Charge-Coupled Devices (C.C.D.'s) and Bucket-Brigade Devices. C.C.D.'s are logically similar to the M.O.S./L.S.I. shift registers but are based upon the controlled movement of electrical charge rather than on transistor-like circuits. They consist of three layers: the semiconductor material, an oxide layer and metal electrodes. C.C.D.'s are potentially more compact, simpler, and lower in cost than conventional integrated circuits. Bucket-Brigade Devices differ from C.C.D.'s in that they can be constructed from discrete components.

Magnetic Bubbles. Again, the logical concept is the same as that of shift registers. The physical phenomenon is based upon the development of "magnetic bubbles" in certain materials that can be made to move along paths on the surface. Although storage and retrieval of data from magnetic bubbles is slower than from other technologies, the bubbles offer the possibility of very low cost through very high densities (1 billion bits per inch has been forecast).

Optical (Laser Beam) and Electron Beam Storage. There are several beam approaches being developed. One strategy is based upon focusing the beam on the surface of a material and, depending upon the intensity, either reading or writing a bit at that spot. Alternatively, using laser and interference pattern (holographic) concepts, an array of information can be accessed at a time. Some devices can both read and write, while others can only read (write once, non-erasable permanent storage). Current components could produce a holographic read-only memory of 10 to 100 million bits with an access time of about five microseconds.

The current prices of storage and the prices anticipated for 1975 are shown in the table on this page. It is important to note that intermediate storage devices are both cheaper and faster than "fixed head" secondary devices such as magnetic drums, in which there is a separate read/write head for every recording position and the appropriate head is electronically selected. But "fixed head" storage represents a small fraction of the secondary storage market. The new intermediate storage devices will coexist with faster, though more costly, main storage and slower, though less costly, "moving head" secondary storage, in which there are fewer read-write heads (which are expensive) than there are recording positions and the heads are mechanically moved from one position to another. The future of these storage levels will depend upon changes in computer system architecture and applications to take maximal advantage of each level's unique characteristics.

	Cost, in cents per byte	*Typical unit capacity, in millions of bytes*	*Random access time, in microseconds*
Main storage (now)	10	.1—1	.6
Secondary storage (now)			
moving head	.01	100	40,000
fixed head	2	10	5,000
Main storage (1975)	1	.1—2	.2
Intermediate storage (1975)	.01—.1	1—20	1—1,000
Secondary storage (1975)	.002	200	20,000

The costs, capacities, and access times of storage now, and projected (by the author) for 1975. "Intermediate storage" signifies a new class of devices now being created that will provide their data faster than secondary storage, but will not cost as much as main storage.

☐ **Archival Storage.** By standards of a decade ago, today's secondary storage devices have enormous capacities. An eight-module IBM 3330 Disk Storage Unit has a capacity of 800 million bytes or "characters." (One byte is not required for a character, but it is generally the industry standard at this time. A byte's eight bits allow 256 different permutations of 0's and 1's—more than enough to encode upper and lower case letters (26 times 2), numbers (10), and punctuation and "control" characters—"carriage return" and others.) If we assume that there are about 4,000 characters on a single-spaced 8½" by 11" sheet of paper, 800 million bytes is comparable to 200,000 sheets of paper. Yet potential information storage requirements greatly exceed this capacity. For example, as part of an anti-trust defense, IBM had submitted over 27 million documents as of January, 1973.

To satisfy these needs, there has been considerable work on the development of "archival storage devices" capable of storing enormous amounts of information economically. These devices are often called terabit memories since they are designed to hold over 1 trillion bits of storage (1 trillion bits is about 120 billion characters, or roughly 30 million 8½" by 11" sheets of paper). There are several archival storages already on the market, including Grumman's MASSTAPE, Ampex's Terabit Memory (TBM), Precision Instruments' UNICOM, and IBM's 1360 Photo-Digital Storage (PDS). They provide direct access to over a trillion bits of storage with a maximum delay of a few minutes. Typical cost per byte is around .001¢. In some devices, such as MASSTAPE and TBM, the information is erasable and rewritable, as in conventional computer storage devices; in others, such as UNICOM and PDS, the information is permanently written and is not erasable (like using ink pens).

Even today, an archival storage unit can hold the capacity of 10,000 conventional magnetic tape reels on-

line—that is, directly retrievable by the computer system. The recording medium is usually removable and can be stored offline, requiring a fraction of the space of a magnetic-tape library. The cost of the recording medium itself drops to around .00005¢/byte. The installation of at least one archival storage device was justified by its elimination of the cost of purchasing, and the space requirement for storing, thousands of reels of magnetic tape. More importantly, by having all of the storage online, slow and error-prone manual handling of magnetic tapes can be eliminated.

An 8½" by 11" document, again assuming 4,000 characters of text, could be stored in computerized form for 4¢ online or .2¢ offline. Thus, it may be cheaper to store information in a computer than on paper! The implications for effective use of archival storage units are not yet fully understood. Experiments in the future uses of archival storages are just beginning, such as the DATACOMPUTER and TABLON projects. This is an area that can have a tremendous impact upon society.

The capacities, speeds, and prices cited are already available on the market. In the next five years, we can expect significant advances, especially in laser and electron beam approaches similar to the UNICOM and PDS units.

☐ **Other Trends.** System reliability will increase due to extensive use of electronic circuits, error-checking and -correcting techniques, and economical redundancy—the use of duplicate elements either to serve as "spares" or to check the correctness of each other. The marriage between computers (and their offspring—terminals) and communications will intensify. Computers are already being used to control communications in A.T.&T.'s Electronic Switching System (E.S.S.). Digital communication, as contrasted with voice communication, is increasing rapidly. This area of tremendous potential is complicated by many factors, including technology, Federal Communications Commission regulations, relatively inexperienced and rapidly growing competition, and A.T.&T.

Computer System Architecture

The computers of 25 years ago were high-speed calculators used to generate ballistic trajectories. Systems are now being used for purposes undreamed of then, yet the basic computer structures have not changed much. As a recent conference speaker stated, "After 25 years of growth, the computer industry has reached its infancy." Research during the past decade is about to pay off in new and more effective approaches to computer architecture.

☐ **Multiprogramming,** the interleaved execution of two or more programs, is standard on most medium and large-scale systems. But the procedures presently needed for multiprogramming are often awkward; they require a large, sophisticated operating system, and frequently introduce considerable performance overhead. By analyzing the fundamental requirements for multiprogram operation and incorporating these features into the computer hardware, operating systems can be made much simpler and more efficient. Rudimentary attempts to accomplish this can be seen in the old Honeywell 800 series and the recent Singer Ten System.

Far more significant approaches can be found in the VENUS Project at MITRE Corporation. In that system, many of the basic multiprogramming primatives, such as those required for synchronization—WAIT and SIGNAL—are provided in the hardware. This enables the VENUS hardware to know which computations are currently executable, and VENUS can automatically select which to run next. Similar experiments exist in the advanced development laboratories of most major computer manufacturers.

Many of these multiprogramming facilities will be compatible with existing software. But to attain even greater effectiveness, especially in the multiple microprocessor system discussed in a preceding section, it will be necessary to develop new programming styles. PL/I (Programming Language/One) provides some of the necessary features for parallelism and synchronization—EVENT variables and the WAIT statement—but other programming languages are needed and are being developed.

☐ **Microprogramming and Control Hierarchies.** The early computers, though voluminous, were relatively simple. They performed additions, subtractions, and comparisons. As users developed requirements for advanced mathematical processing (vector and matrix operations, for example), extensive non-numerical processing (such as character code conversion or information retrieval), and intricate problem-solving, far more sophisticated computers were desired. The microprogramming manufacturing technique makes it feasible and economical to produce such systems. There are many low-level hardware functions (for example, setting a bit, starting up the main memory, or moving information between internal registers) required to accomplish one "instruction" such as *ADD X to Y*. In a microprogrammed computer, these low-level functions are controlled by a "microprogram" that indicates the steps required to accomplish each instruction. These microprograms are much easier to change and design than it is to use conventional direct electronics to generate the control signals for the low-level functions. In the VENUS Project, many of the operating system functions (for example, synchronization, interlocks, memory mapping, and allocation) have been incorporated into the basic computer microprogram hardware (called "firmware"). This approach has also been used to greatly simplify and speed up the operation of high-level programming languages (we will discuss programming languages later in this article), such as COBOL, FORTRAN and PL/I on the Burroughs 1700 system, and APL on an experimental IBM system. This trend will continue on future systems, providing far more powerful and efficient programming facilities.

☐ **Virtual Storage and Storage Hierarchies.** IBM has recently popularized the concept of "virtual storage," the automatic management and movement of information between main storage and secondary storage. Similar approaches have been used in many earlier systems by other manufacturers, such as Burroughs and RCA (now UNIVAC). Virtual storage greatly simplifies the tasks of the programmer—the major cost in application development as well as in improving system performance. It does so by eliminating explicit constraints on program size caused by limitations of main storage capacity and by eliminating much of the explicit concern for "efficient" use of main storage. If information is needed, it is auto-

```
                DECLARE A(10),B(10);
                A = A + B;

                DIMENSION A(10),B(10)
                DO 100  I = 1,10
100             A(I) = A(I) + B(I)

A               DS      10F
B               DS      10F
                LM      1,3,=F'0,4,36'
X               LE      0,A(1)
                AE      0,B(1)
                STE     0,A(1)
                BXLE    1,2,X
```

A short lesson in computer programming to demonstrate the differences between high-level and low-level programming languages. Shown above are segments from three computer programs, each of which produce the same result: the addition of two vectors A and B, where each vector is a collection of ten quantities. The first segment is composed of two statements in the high-level language PL/1; the second consists of three statements in the high-level language FORTRAN; the last consists of seven statements in IBM 360 Assembler, a low-level language. (In all three segments, we disregard the matter of introducing the data into storage.) The DECLARE statement in PL/1, the DIMENSION statement in FORTRAN, and the DS (Designate Storage) statements in 360 Assembler all serve the same function: they reserve space in storage for two collections of ten quantities each, and name the beginnings of the storage locations A and B. In PL/1, only one additional statement is necessary to add A to B and store the result where A was stored. In FORTRAN, two statements are necessary; the computer is instructed to execute statement 100 ten times, each time incrementing the "counter" I by one, until all ten elements of A are added to the corresponding elements of B. In 360 Assembler, the programmer's work is considerably more complicated. The programmer must explicitly arrange for the movement of the elements of the vectors in turn from storage into the processor, must write a conditional branching instruction to perform a comparison between a counter and a constant (which he must provide to the processor) to check if all ten elements have been added, and have the computer "branch" back to the beginning if the computation is not complete. Computers can execute only instructions even simpler than those of Assembler language; high-level languages are translated into these basic statements by computer programs called compilers.

matically moved into main storage. If main storage becomes overcrowded, information is automatically moved to the slower and cheaper secondary storage devices. In addition to easing application development, these techniques often lead to improved overall system performance.

The effective use of the intermediate storage technologies we described earlier requires an automatically controlled storage hierarchy that provides a virtual storage encompassing main, intermediate, and secondary storage. Research in this approach is going on in development laboratories as well as universities, including M.I.T. The current problems will probably be resolved in time to allow the use of intermediate storage devices in storage hierarchies for the next generation of computer systems. The combined effect should further reduce programming costs while increasing system efficiency.

☐ **Remote Computing.** One of the most significant impacts of information processing systems will be in this area, which includes time-sharing, centralized data bases, and computer networks.

Time-sharing, the simultaneous access to, and shared use of, a centralized computer by users at remote terminals, has not met the lofty projections of its advocates during the mid 1960's, but it has, and will continue to have, tremendous effects. Most of the earlier technical problems have been long overcome and the reduced system cost makes time-sharing systems very attractive. Many people, "burnt" during the expensive time-sharing fever of the 1960s, are surprised to find that powerful time-sharing systems are commercially available for less than $20,000 a month (such as the VM/370 operating system on the IBM System/370 Models 135 or 145). More limited time-sharing systems, such as those utilizing minicomputers and restricted to the BASIC programming language, are available for a fraction of IBM's price. At the other extreme, powerful "computer utilities" capable of handling hundreds of simultaneous users have finally reached the marketplace. These include the new Honeywell H6180 Multics (Multiplexed Information and Computing System) which was developed in conjunction with M.I.T.'s Project MAC.

The full impact of time-sharing systems has been stalled by the lack of entrepreneurial efforts in application areas. We are now beginning to see the emergence of companies that use the time-sharing concept to provide useful and convenient facilities directly to the end-user—the user of an application-oriented program, who is usually not a programmer. Typical application areas include online advertising media analysis, engineering/manufacturing/production control systems, and sophisticated lens-design programs. Many of the larger time-sharing services companies have already found that most of their revenue is derived from the proprietary application program services rather than from their traditional "raw" computer services.

As the complexity of modern-day business increases, it is necessary to place increased reliance upon computer-assisted controls. New information-handling concepts coupled with the economics of secondary and archival storage devices make centralized data accessed through remote terminals feasible. Many of the earlier disasters of "online real-time total management information systems" can be attributed to the naivety of the users and implementors rather than interpreted as an indictment of the basic concepts.

The developing need for more global optimization of large systems, used by such concerns as a decentralized manufacturing company or perhaps the Federal Reserve System, makes it necessary for local computer systems to communicate and exchange information. Advances in this area are being made by projects such as the government-funded ARPANET and Michigan's MERIT

system. Commercial versions of these systems are already appearing on the market (for example Bolt, Beranek and Newman's Interface Message Processor systems originally developed for ARPANET).

☐ **Protection.** The topics of information system protection and security have received considerable attention in the press, but their full implications are probably not yet apparent to most observers. It is unlikely that anyone would make a serious attempt to steal your company's payroll program or even the customer list—although it is possible. On the other hand, consider a multi-million dollar software development company whose major assets—proprietary application programs—may be represented by a single reel of magnetic tape. The lack of effective technical and legal safeguards has been a major obstacle to the growth of the application-oriented time-sharing services market. Fortunately, many, though not all, of the problems have been solved.

It is useful to divide the problem of protecting the information in a computer system into three parts: *validation* (How is bad information kept out of the system?); *integrity* (How is destruction or loss of information prevented?); and *security* (How is unauthorized access to the information prevented?).

It makes little sense to lock your information system in a lead vault guarded by Marines if the information is meaningless or incorrect. In a

```
ENTER REQUEST: assembly y inner gimbal assy
QUANTITY  PART-NUMBER  DESCRIPTION
: 2       z            bearing assy
: 1       300          ring
: .

ENTER REQUEST: assembly z bearing assy
QUANTITY  PART-NUMBER  DESCRIPTION
: 2       100          ball bearing
: 1       200          pin
: .

ENTER REQUEST: assembly xx outer gimbal assy
QUANTITY  PART-NUMBER  DESCRIPTION
: 1       y            inner gimbal assy
: 2       z            bearing assy
: 2       300          ring
: .

ENTER REQUEST: assembly ww housing assy
QUANTITY  PART-NUMBER  DESCRIPTION
: 1       z            bearing assy
: 4       100          ball bearing
: .

ENTER REQUEST: explode xx summarized
GROSS SUMMARIZED QUANTITIES FOR
QUANTITY  PART-NUMBER  DESCRIPTION
    1     XX           OUTER GIMBAL ASSY
**********************************
    1   * XX           OUTER GIMBAL ASSY
    1   * Y            INNER GIMBAL ASSY
    4   * Z            BEARING ASSY
    8     100          BALL BEARING
    4     200          PIN
    3     300          RING
* INDICATES ASSEMBLY SHOWN FOR REFERENCE ONLY.

ENTER REQUEST: explode multiple summarized
QUANTITY  PART-NUMBER
: 5       xx
: 3       ww
: .
GROSS SUMMARIZED QUANTITIES
      . . .
  58      100          BALL BEARING
      . . .

ENTER REQUEST: enter-info part on-hand
PART-NUMBER  ON-HAND
: y          3
: z          2
: 100        20
: .

ENTER REQUEST: explode multiple summarized net
QUANTITY  PART-NUMBER
: 5       xx
: 3       ww
: .
GROSS  O/H  NET  PART-NUMBER  DESCRIPTION
     . . .
   58   20   22  100          BALL BEARING

ENTER REQUEST: enter-info part y on-hand 6

ENTER REQUEST: explode multiple summarized net
     . . .
   58   20   14  100          BALL BEARING
```

A simple example (that manages to become fairly involved) of an information system to be used by a manufacturer at a remote computer terminal. Lower-case typing is by the user; upper-case typing is by the computer; "ENTER REQUEST:" Initiates each exchange of information. The user has begun by listing the component parts of an inner gimbal assembly, a bearing assembly, an outer gimbal assembly, and a housing assembly. This information is stored by the computer. The user then requests a summary of the parts required for an outer gimbal assembly ("explode xx summarized"), and the number of ball bearings required for a production run of five outer gimbal assemblies and three housing assemblies ("explode multiple summarized"). Finally, the user enters the quantities of assemblies now in stock ("enter-info part on-hand"), and wishes to know, first, how many ball bearings are required for a given production run ("explode multiple summarized net"), and then how many are required if it were six rather than three inner gimbal assemblies (part y) in stock. (Source: MITROL, Inc.)

New Jersey town preparing the data for computing the tax rate, a value of $10,000,000 for one resident's house was incorrectly placed in computer storage. (A decimal point was misplaced or a keypunch operator was sleepy.) After the tax rate was computed, the mayor was pleased to announce that the town had one of the smallest rate increases in the state. Months later, an irate resident complained of a $10,000,000 property assessment on his 8-room house. At last report, the mayor was looking at a sizable budget deficit.

Techniques have been developed to prevent the loss of information stored in a system. These include "backup" copies that are automatically generated (for example, by the Multics backup system) and duplicate copies that are automatically maintained.

Security, and the related issues of privacy, have received considerable attention. Modern computer systems provide facilities, such as "supervisor" and "user" modes of operation, to help enforce security. Due to the complex interdependencies of information and users, it has been difficult to develop security techniques that are exactly sufficient for their intended purpose and yet do not impose unnecessary constraints on system use. M.I.T.'s Sloan School Information Systems Security Project is investigating these problems as part of IBM's 5-year $40 million joint research effort in conjunction with university, industry, and government investigators.

Systems that are Easier to Use

We have thus far presented advances that are driven primarily by technological innovation in hardware manufacturing and system architecture. It is reasonable to ask, "What about the user?" In addition to the unselfish desire to make life more pleasant for users, there are many important dollars-and-cents reasons that are accelerating manufacturers' and researchers' efforts. If the prices of hardware drop as anticipated, it will be possible to do next year's processing at less cost than this year's. One estimator claims that the current world-wide inventory of processors and memories could be replaced at a cost of less than $1 billion by 1975. Thus, if there is not continual and massive growth of the market, the industry will stagnate—and its dollar rev-

```
Pick up a big red block.
     OK.

Find a block which is taller than the one
you are holding and put it into the box.
     BY "IT", I ASSUME YOU MEAN THE BLOCK
     WHICH IS TALLER THAN THE ONE I AM
     HOLDING.
     OK.

What does the box contain?
     THE BLUE PYRAMID AND THE BLUE BLOCK.

Will you please stack up both of the red blocks
and either a green cube or a pyramid?
     OK.

Which cube is sitting on the table?
     THE LARGE GREEN ONE WHICH SUPPORTS THE
     RED PYRAMID.

Is there a large block behind a pyramid?
     YES, THREE OF THEM: A LARGE RED ONE, A
     LARGE GREEN ONE AND THE BLUE ONE.

Put a small one onto the green cube which
supports a pyramid.
     OK.

Put the littlest pyramid on top of it.
     OK.

Does the shortest thing the tallest pyramid's
support supports support anything green?
     YES, THE GREEN PYRAMID.

Had you touched any pyramid before you put the
green one on the little cube?
     YES, THE GREEN ONE.

When did you pick it up?
     WHILE I WAS STACKING UP THE RED CUBE, THE
     LARGE RED BLOCK AND A LARGE GREEN CUBE.

Why?
     TO GET RID OF IT.

Why did you do that?
     TO CLEAN OFF THE RED CUBE.

Why did you clear off that cube?
     TO PUT IT ON A LARGE GREEN CUBE.

Why did you do that?
     TO STACK UP THE RED CUBE, A LARGE RED
     BLOCK AND A LARGE GREEN CUBE.

Why did you do that?
     BECAUSE YOU ASKED ME TO.
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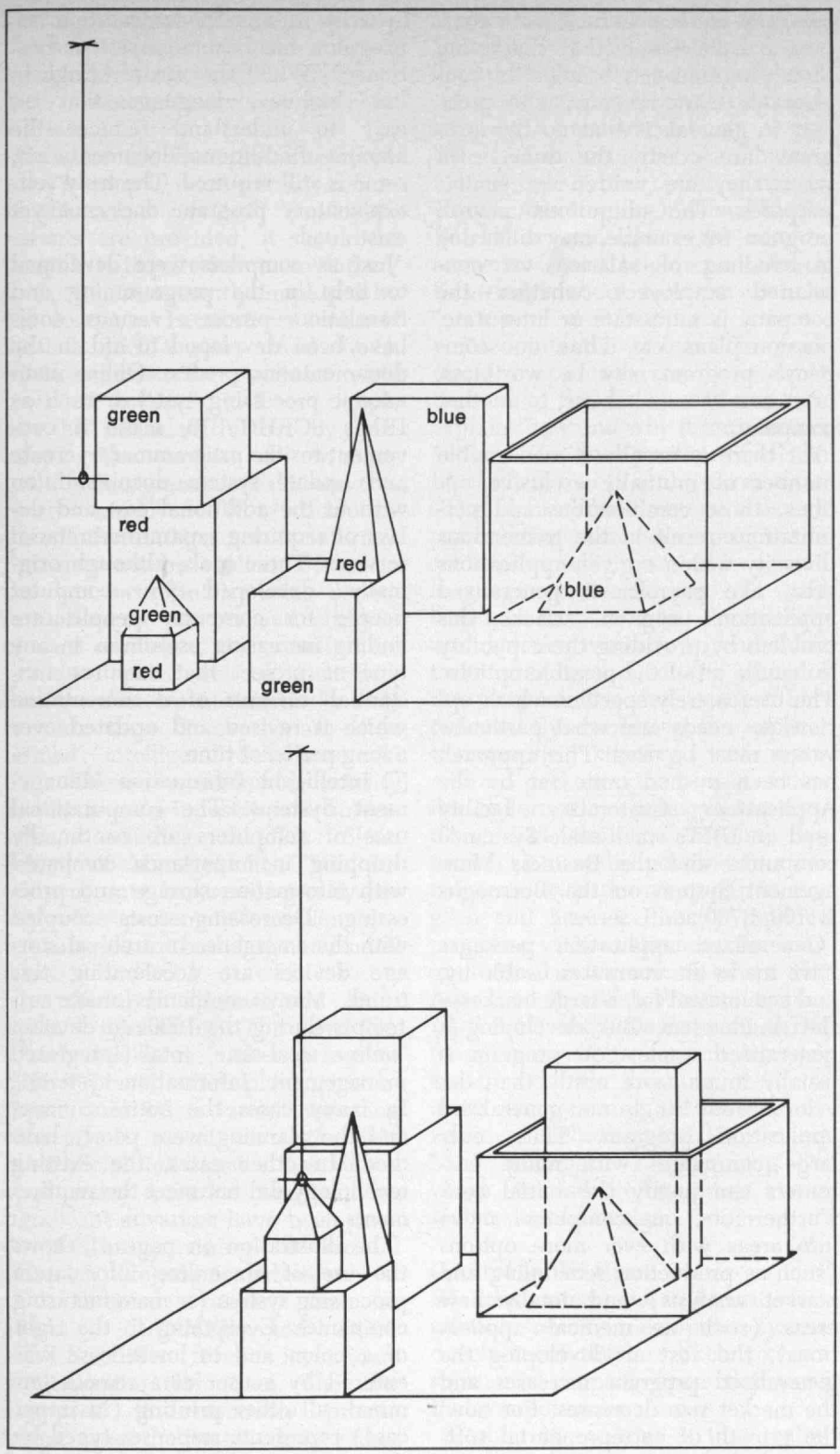

At left, some sample dialog from the Blocks World System, created by Professor Terry Winograd at M.I.T.'s Artificial Intelligence Laboratory. The system includes a computer programmed to understand English-like language. Human commands and questions concerning a scene containing a table, a "hand," an open box, and an assortment of blocks and pyramids are in lower-case typing; the computer's responses are in upper-case typing. The system responds with an "OK" after executing an order. Examples of its processing: For the second request, the computer must deduce which block it is holding and determine the referents of the words "one" and "it." In the command to "put a small one onto the green cube," the system interprets "one" in light of the previous request to mean a block. Later, the meaning of "littlest," a word not yet in the computer's vocabulary, is surmised from the computer's knowledge of the word "little." The drawing above shows the initial and final states of the scene.

enues will shrink tremendously.

All these gloomy statements have potentially applied over the past 25 years. Fortunately, the market has always grown much faster than prices could drop, and a demand has developed for larger and more powerful systems. When the early ENIAC computer was built, reliable experts predicted that 100 such machines would satisfy the country's computational needs for the rest of the century. Needless to say, the market was somewhat larger.

We will take the position that there is enormous potential market growth for computerized processing and information systems. But we can identify three major bottlenecks to growth:

Salaries vs. Hardware. It is estimated that close to 70 per cent of the development and operation costs of new application areas is tied to people (including their salaries, office space, fringe benefits, etc.) and only about 30 per cent is tied to computer hardware. If the hardware costs were to drop to zero, there would still be relatively little increased incentive to develop applications at a faster pace.

Maintenance vs. Development. In most mature data processing installations, about 80 to 90 per cent of the personnel and costs are devoted to the operation and maintenance of existing applications. This leaves only about 10 to 20 per cent of the budget for the development of new application areas.

User Sophistication and Education. The first two bottlenecks relate primarily to the market of current, relatively mature users. An even larger market is found in present non-users, frequently representing small and unsophisticated concerns. The third bottleneck is tied to making systems usable by the uneducated non-user.

In this section we will discuss approaches and techniques, in existence or being studied, that attack these bottlenecks.

☐ **High-Level Languages and Problem-Oriented Languages.** A "machine language"—the language in while each statement represents a single instruction to a computer—is awkward and tedious for human use in expressing a problem. Instead, the user expresses his problem in an "English-like" high-level language (H.L.L.), such as FORTRAN (**FOR**mula **TRAN**slator) or COBOL

(COmmon Business Oriented Language), and the computer translates the problem into machine language, using a computer program called a compiler. The net effect is that it is easier and faster for the user to write computer programs.

The illustration on page 40 shows the amount of effort required to specify a vector addition using two H.L.L.s—PL/I and FORTRAN—and the "assembly language" (low-level language) for the IBM System/360 computer. The PL/I and FORTRAN forms are converted to the low-level form by the appropriate compilers.

A Problem-Oriented Language (P.O.L.) is a high-level language specialized for a particular application area. For example, the COGO (Co-ordinate Geometry) language is intended for use by civil engineers, and provides facilities for conveniently expressing arcs, angles, areas, and so on.

H.L.L.s and P.O.L.s have been in use for many years. But in the past, it has been expensive and difficult to implement compilers. Some H.L.L.s and P.O.L.s have not been much easier to use than machine language. Finally, the use of H.L.L.s and P.O.L.s often resulted in programs that were less efficient than programs manually translated into assembly language. These problems have been largely overcome, due to research resulting in techniques that produce economical, efficient, and more powerful compilers; the shift in cost from computer hardware to people, so that even if the compiler is inefficient, a manual translation would usually be much more expensive; and new computer architectures that provide for efficient operation of H.L.L.s and P.O.L.s—such as an experimental computer system, employing microprogramming that directly executes APL (**A P**rogramming **L**anguage) statements rather than assembly language instructions.

☐ **Generalized Application Packages.** While high-level languages make programming easier, they still require programmers. Yet every company seems to want a payroll program, an inventory control program, an accounts receivables program, and so on. The vast majority of current programmers are working on projects that have already been done at other companies.

The problem is usually not due to company secrecy. In fact, some companies have found that marketing their programs has brought in considerable extra revenue. The problem, in general, is that no two programs are exactly the same, even when they are written for similar purposes. The ubiquitous payroll program, for example, may differ due to handling of salaried vs. non-salaried employees, whether the company is intra-state or inter-state, pension plans, etc. Thus, one company's program may be worthless, or at best of minimal use, to another company.

Yet there is usually a manageable number of mutually exclusive options whose combinations and permutations result in the tremendous diversity within a given applications area, like payrolls. A generalized application program attacks this problem by providing the capability to handle all of the possible options. The user merely specifies which options he needs and what particular values must be used. This approach has been pushed quite far by the Applications Customizer facility used on IBM's small-scale System/3 computers and the Business Management System on the Burroughs B1700, B700 and L series.

Generalized application packages have made the computer usable by, and economical for, a large market—the small users. But developing a generalized application program is usually much more costly than developing any single non-generalized application program. Thus, only large companies with many customers can justify the initial cost. Furthermore, as computers move into areas with ever more options (such as production scheduling and market analysis) and totally new areas (such as medical applications), the cost of developing the generalized program increases and the market size decreases. For now, the growth of entrepreneurial software companies, in addition to the present computer manufacturers, will result in considerable activity in the generalized application package area.

☐ **Information Handling and Documentation.** The actual writing of computer programs is only part of the cost of developing new systems. The use of high-level languages has made some programmers so effective that it takes more people to explain how to use the software than it took to write it. The "documentation" of programs has become a serious bottleneck. While the use of "English-like" high-level languages that are easy to understand reduces the amount of additional documentation, some is still required. The truly self-explanatory program does not yet exist.

Just as compilers were developed to help in the programming and translation process, various tools have been developed to aid in the documentation process. Online manuscript processing systems, such as IBM's SCRIPT/370, make it convenient for the programmer to create and update system documentation without the additional cost and delays of requiring separate secretarial services. These tools, although originally developed by computer people for computer people, are finding increasing usefulness in any type of project that requires substantial amounts of documentation which is revised and updated over a long period of time.

☐ **Intelligent Information Management Systems.** The computational uses of computers are continually dropping in importance compared with information storage and processing. Decreasing costs coupled with the emergence of archival storage devices are accelerating this trend. Many companies made attempts during the 1960s to develop "online real-time total integrated management information systems." In many cases the entire concept and the planning were poorly handled. In other cases, the existing technology did not meet the requirements.

The illustration on page 41 shows the use of an online information processing system for manufacturing companies. Everything to the right of a colon and in lower case was entered by a user at a remote terminal; all other printing (in upper case) represents responses typed by the computer. The user can describe, for permanent storage, how his manufacturing assemblies are put together. Once the information has been entered, questions can be asked—fairly straight-forward questions, but ones that are deceptively difficult to unravel in companies with thousands of parts and hundreds of products. By exploiting modern information management technology, good "human engineering" (ease of use) and the time-

sharing concept, powerful systems are now available to manufacturing companies that couldn't afford or didn't want in-house computer facilities.

Consider an example of a company's computerized personnel files. If the names of each employee's parents are provided, it should be possible to inquire how many father/son pairs are currently employed by the company. In most conventional systems, such a query could not be made unless the system were modified to handle it. This example can be extended further by considering the question of how many grandfather/grandson pairs are currently employed. Note that the grandfather-and-grandson information may not be explicity stored in the data base. But by using the information on parents and children of each employee, the grandfather/grandson pairs can be identified. Systems that are automatically able to make these discoveries are often termed "intelligent" data base systems. There is considerable activity in this area in industry and universities, including M.I.T.'s Sloan School of Management. These intelligent data bases will greatly enlarge the present information systems market for both large and small users.

☐ **Artificial Intelligence and Automatic Programming.** The term "artificial intelligence" often brings to mind robots, chess-playing computers, and other far-out sounding concepts. In recent years, the field of artificial intelligence has developed many concrete results. Two significant advances have been goal-directed programming and natural (English) language capabilities.

Goal-directed systems, such as M.I.T.'s PLANNER and CONNIVER, differ from conventional programming techniques. The user expresses, in reasonably precise terms, *what* he wants done rather than the *how*-he-wants-it-done required by conventional programming. This approach makes it easy and convenient to build larger and more complex systems and puts much of the mechanical problem-solving burden on the computer rather than on people.

The example presented on pages 42-43 illustrates the use of goal-directed techniques as well as recent results in natural language understanding. This work was performed at the M.I.T. Artificial Intelligence Laboratory. At the right is a collection of blocks as seen by a mechanical eye. These blocks can be manipulated by a mechanical hand. At the left is a dialogue between human (lower case typing) and computer (upper case typing). The "Blocks World" system allows the user to converse about children's blocks. Knowledge about concepts such as "on top of" and "supports" is incorporated into the system. The goal-directed approach can be seen at the end of the dialog as the system explains how and why it took certain actions. The final position of all the blocks is shown in at the lower right.

The Blocks World system, although representing tremendous progress in artificial intelligence and natural language understanding, is still largely a "toy" system. Researchers are exploring ways to extend these techniques toward solving many of the programming development bottlenecks. By combining the application-specific knowlege of generalized packages, the power of flexible information management systems, and the goal-directed approach, it may be possible to communicate with the computer in English and have it directly produce programs without the need for "programming" as it currently exists. The Advanced Research Projects Agency (A.R.P.A.) of the Department of Defense is funding research in such areas, under the heading of "automatic programming," at several universities, including M.I.T.'s Project MAC Automatic Programming Division. A similar effort exists at the University of Michigan.

Control by the Users

We have attempted to identify significant trends in computer system development that are likely to have substantial impact upon the ways that computers are used.

A point to consider is that realizing the full potential of these advances depends on making dramatic changes in information system usage and structure. In many cases, these changes are more under the control of information system users than manufacturers. An informed user community is an important requirement for future progress.

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Arthur Saltzman
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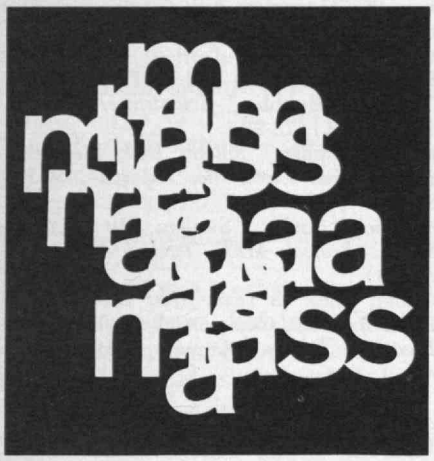
Para-Transit: Taking the Mass Out of Mass Transit



Arthur Saltzman comes to transportation through academic work and experience in science and management. His undergraduate work was in physics (Brooklyn College), and after a six-year career in the aerospace industry and with N.A.S.A. he came to M.I.T.'s Sloan School of Management for a master's degree (1966). Three years later—after administrative work in the M.I.T. Instrumentation Laboratory—Mr. Saltzman joined the CARS Project, a dial-a-bus system demonstration, in the M.I.T. Urban Systems Laboratory. Since 1970 he has been in charge of the interdisciplinary Transportation Institute at North Carolina A & T State University, where research centers on transportation needs of the urban poor and other carless people in an age dominated by the automobile.

A lot of transportation planning has gone on in our cities in the past ten years in which conventional mass transit is the proffered alternative to private automobiles. But mass transit is designed to move many people between a few places. Its capital and operating costs are high, so when residential densities are low and commercial and industrial sites dispersed it draws too few riders to cover them. In these situations—for example, the suburbs—public transportation is either not attempted at all or it is provided with limited frequency and coverage.

Yet what were once compact cities with populations concentrated along radial spokes are now enormous and dispersed metropolitan areas. Since 1950, the San Francisco metropolitan area has grown from 282 to 1,122 square miles; that of Washington, from 181 to 523; that of Miami, from 116 to 429. America's suburbs now contain the largest part of her population. Her 25 largest cities gained 710,000 people in the 1960s, and her 15 largest metropolitan areas gained almost 9 million. A city's suburbs now commonly outnumber the city's population two, three, or four times over.

A good part of our urban population is without adequate public transportation. In suburban areas, those who have no access to an automobile are likely to have severe mobility problems, especially the poor, the elderly, the handicapped, and those too young to drive.

There are, however, alternatives: modes such as taxis, jitneys, dial-a-ride, car pools, subscription buses, and minicars, the modes we collectively call "para-transit." They could be called "transit" because they provide public transportation, but that word usually refers to regularly scheduled bus and rapid rail service. Besides serving low-density suburbs and small cities the para-transit modes are useful within central business districts of large cities, to bring groups of workers directly to their places of employment, and to feed line haul bus routes and rapid transit lines.

Both local and federal agents have become interested in these innovations in transportation which are ready for use and do not require development of sophisticated equipment or construction of new roadways.

This paper will focus on dial-a-ride, a para-transit mode which has in recent years been the subject of substantial research and a number of demonstration experiments in various cities. To show the context of its introduction I will describe the transit industry's traditional response to competition from another flexible, demand-responsive para-transit mode, the jitney.

"Unbusinesslike"—But Wanted

Adapting to changes in the patterns of urban living has always been difficult if not impossible for the transit industry. It decided early in its history that urban transportation needs could best be served by large vehicles operating along fixed routes. The horse-drawn omnibus gave way to the electric streetcar that ran on tracks and derived its power from either overhead or underground sources. By 1914, urban public transportation was being provided almost exclusively by electric street railways.

The electric street car—the trolley—was the principal force in shaping the use of land in and around American cities in the late 19th and early 20th centuries. It made possible

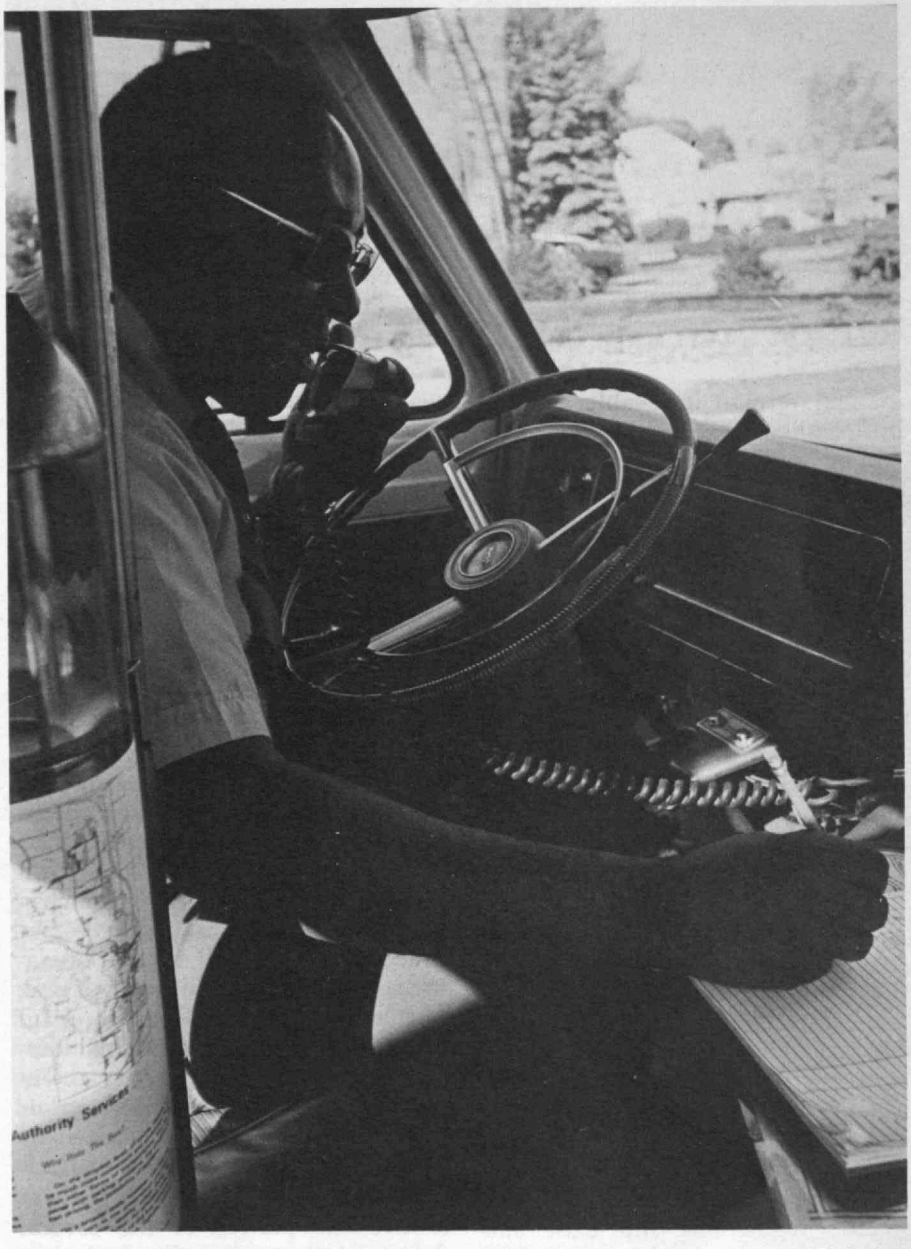
The jitneys of the 1920s made the mistake of competing with—or seeming to—the established networks of fixed-route transport. Now we are rediscovering the promise of para-transit—jitney systems with modern communications (hence dial-a-bus)—for meeting low-density transit demands.

a broader and more decentralized urban area by allowing workers to commute to their jobs from greater distances than had been previously possible. So began the movement from city to suburb.

The first challenge to the trolley's monopoly came in 1914 in Los Angeles. A Model T Ford began to cruise along a trolley route and pick up passengers for some vaguely defined suburban place, such as Long Beach. The Los Angeles jitney—jitney used to mean nickel, the fare—gave its passengers fewer stops and probably took them closer to their destinations than a trolley would.

Jitneys were what we call "demand-responsive." More jitneys would operate along more densely travelled corridors; the owner-driver would try to pick up passengers from different stops who were going to clustered destinations; he would try to arrange his route so as best to serve the destinations of his customers. In some cases, for an extra charge the driver would take a passenger to his exact destination.

The depression which followed the outbreak of war in the autumn of 1914 produced a large supply of unemployed men who used their automobiles to earn their livings. The notion of jitneys spread rapidly in California and, within a few months, across the nation. Their appearance in Portland, Maine, in March of 1915 indicated they were viable in more severe climates. The trade organ, *The Jitney Bus,* which was founded that same month estimated there were 62,000 jitneys operating at their peak. By 1917, street railway operators were going to great lengths to prove that the jitney was a serious menace to conventional transit. They alleged that jitney op-



Early in its history American public transportation became organized on the basis of large vehicles operating along fixed routes. And adapting to changes in living patterns "has always been difficult if not impossible for the transit industry," writes Arthur Saltzman. Hence the considerable reluctance of established companies to look at the modern equivalent of the "jitney," the small telephone-summoned bus which the author has studied at M.I.T. and more recently in North Carolina. (Photo: Ford Motor Co.)

The character of American urban transportation today may well have been established by the electrified street railways in the 19th century; success was then attained by frequent, high-capacity services on fixed routes. Few realize that this system was challenged early in the 20th century by low-capacity, flexible-route "jitneys," which, says the author, were "regulated out of existence."

erators were so unreliable and unbusinesslike that they actually lost money in providing the service. This was true for many naive operators, who neglected to include depreciation in their costs.

The large increase in the number of inexperienced operators, a scarcity of parts and fuel, and harassment from the streetcar interests decimated the jitney industry.

According to "Public Convenience"

Instead of introducing better and more varied public transportation services, the transit industry's response to competition was to try to regulate it out of existence.

This early legislation temporarily reestablished the monopoly of the street railways except in the areas of non-common carrier and single-usage taxicab operations. Almost every city had an anti-jitney ordinance; usually the transit franchise stipulated that fixed routes were to be established according to "public convenience and necessity."

These regulations still exist and could block the implementation of new systems such as the demand-responsive para-transit modes.

Many of the jitney operators who were able to survive the first repressive regulations began to operate their vehicles as streetcars. *The Jitney Bus* changed its name to *The Motor Bus* in September, 1915, and implored its readers to establish fixed routes and schedules and build "streetcar-like" bus bodies, in order to appear more "legitimate" to the public and the authorities. Some jitney operators became feeders to streetcar and electric interurban trunk routes; others sold out to the electric railway interests and accepted employment as the managers of a railway's motorbus division.

In rare cases, the weakness of anti-jitney ordinances or the lack of enforcement permitted jitneys to survive and continue to offer more flexible, if not more reliable or comprehensive, services than the established, conventional transit operators. For example, Mayor Frank Hague of Jersey City was powerful enough to prevent the Public Service Railway Company (a giant in its own right) from enforcing or having enacted such ordinances. As a result, jitneys proliferated in Hudson County and eventually there formed the pattern of the several dozen one or two small-vehicle bus operators which is found there today. Service is probably not worse there than in neighboring New York City where most of the transit operations come under one publicly operated monolith.

The jitney operation in Atlantic City, New Jersey, which can trace its origin back to the jitney craze of 1916, is a more conventional one which still persists. Vehicles are individually owned, although a cooperative association enforces rules of operation. Until 15 years ago, Atlantic City jitney operators would take passengers to their destinations for twice the prevailing fare if the operator were near the end of his route and the destination only a few blocks away. Similar legalized jitneys still operate on Mission Street in San Francisco and did so until 1965 in St. Louis.

The restrictions that require fixed routes were intended to eliminate the jitney in favor of the streetcars. However by the early 1920s streetcars were giving way to motor buses, which were cheaper to operate and more flexible because of their ability to make instant changes in routes. The replacement of trolleys by buses—"bustitution," as it is acrimoniously described by trolley fans—has been almost complete in the United States although there are still operations in a few cities such as Washington, Boston, Newark, Pittsburgh, Philadelphia, San Francisco, and New Orleans. Also near complete has been the reluctance of transit operators to use to advantage the flexibility of buses. Routes rarely change even though the locations of population and employment do so constantly.

A resurgence of jitney operations cannot take place in the United States unless the restrictive regulations are removed from the law books. Undoubtedly the established transit operators and regulatory agencies would fight to preserve their monopoly. The jitney kind of public transit is still an anathema to most transit operators: the mere mention of jitneys by this author has been known to provoke them to lecture upon their evils.

Various pressures, however, may force a change. The current trends in transportation demand the more diffuse routes that jitneys could serve. The suburban explosion has put more and more of the population in less dense areas, and the jitney and other kinds of para-transit seem more likely to provide economical service to them than conventional transit.

Transit routes in most low density areas are either nonprofit or

nonexistent. Many bus routes have been discontinued when there was still sufficient demand along these routes to support jitney operations. Jitneys need lower revenues per mile than buses to cover costs or make a profit and can therefore be viable along less heavily travelled routes. Indeed, their superior service would attract more passengers than buses along any given route: perhaps they should be restricted to low-density areas so they do not skim the cream off the bus operations.

Jitney operators, being locally attuned, may also discover new routes, profitable for them, that have never been exploited by established operators.

The presence of "gypsy taxis" and illegal jitneys in low income areas all over the U.S. is evidence of the demand for this type of service. These gypsy taxis often appear where the established transit operation has failed to provide a needed service. We know little about how common they are, but an example is the illegal jitney system that operates between downtown Pittsburgh and the black communities of Homewood, Northside, and the Hill district. Transit service is inadequate and taxis are reluctant to serve black neighborhoods: the jitney operators feel they are providing a community service as well as earning money. Persistent opposition by the Public Utilities Commission, the transit operator, and local taxi companies have failed to eliminate them. Lately the official attitudes towards these jitney operators have even mellowed because of community support.

It should be noted that almost every employment facilitation project conducted in low-income areas made reference to legalizing such operations. For example, a report from one in New York suggests "an entirely new approach with consideration being given to less organized and more *ad hoc* arrangements such as the encouragement of car pools. . . . or through the establishment of the low-fare, owner-operator, jitney or taxi-type services for the carless population." Many people who could not afford a private automobile might then own one based on its potential for producing income. Allowing jitneys to operate in any area could bring significant new employment possibilities to the poor or jobless and supplemental income opportunities for anyone who had a vehicle in good condition.

Is this the modern "jitney"? Over a dozen dial-a-ride experiments have taken place in the U.S. and Canada in the last few years, most of them using vehicles such as this which was tested during M.I.T. research on the concept early in the 1960s. The basic plan is for a telephone-controlled, flexible transport system which gives door-to-door service at less than the cost of a taxi.

Dial-a-Ride: More Sanctioned

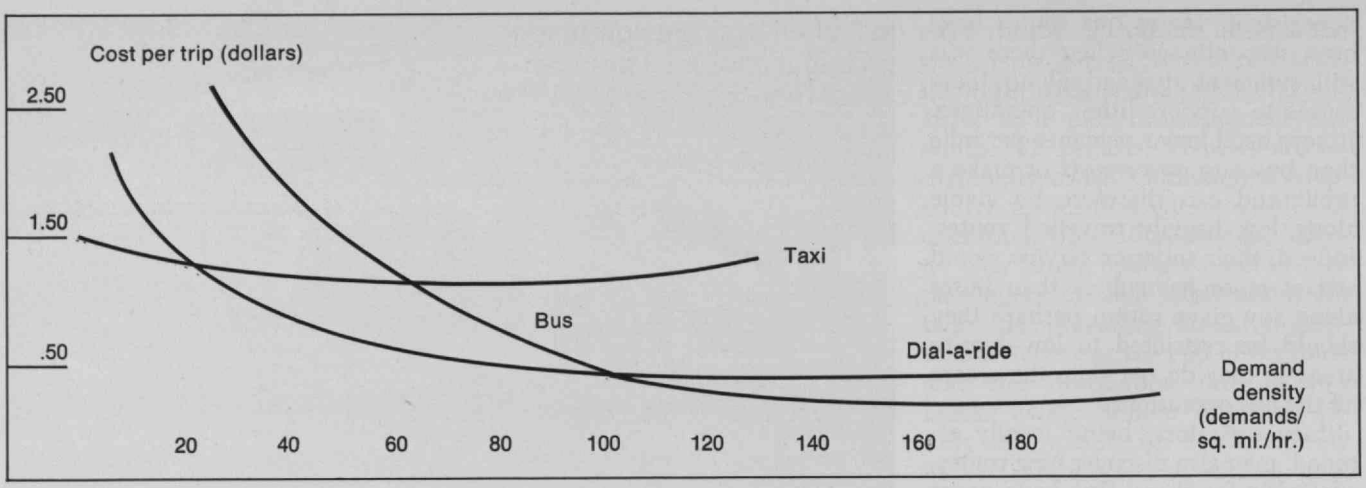
A para-transit mode which would probably appeal more to transit operators than jitneys is a hybrid of a conventional bus and a taxi known as dial-a-ride—and this is so far the most widely introduced. It operates so several passengers share the cost of door-to-door service. To use it, a customer telephones the central dispatcher and tells him his point of origin, his destination, and the number of passengers. The dispatcher assigns a vehicle to handle the request either manually or with computer help and tells the customer how long the wait will be. By radio, he tells the driver of the assigned vehicle to make the pickup.

Research on dial-a-ride was begun in the early 1960s by M.I.T., Northwestern University, and General Research Corporation. Both the Ford Motor Company and General Motors Research Laboratories have participated. These research efforts have developed a body of knowledge about computer-based scheduling and dispatching, vehicle design, and radio communications systems. Without distracting from these accomplishments, I should state that the technical problems to be overcome were relatively small compared to the social, economic and institutional ones.

The earliest theoretical studies usually concluded that the technology behind a dial-a-ride system would be relatively simple and based on equipment and software already in existence. The system would put together a communication network and computer-based routing and scheduling algorithm less complex than systems the airlines have used for years.

The more difficult questions were what the demand would be, whether dial-a-ride would be financially feasible, and how to implement it. D.A.R. simulations at M.I.T. suggest it might be economical and attractive for areas with population densities of 2,000 to 6,000 persons per square mile—even in competition with scheduled buses at the higher densities. By 1985, some 60 million people will probably reside in areas within that range. The system might even be successful at much higher densities: buses would be more economical, but D.A.R.'s higher quality of service would serve more needs.

A General Motors Corp. study estimated the demand for a proposed dial-a-ride system in a city of 200,000 residents. Although only 1 per cent of all trips were currently being made by public transit, a D.A.R. system, because of its superior ser-

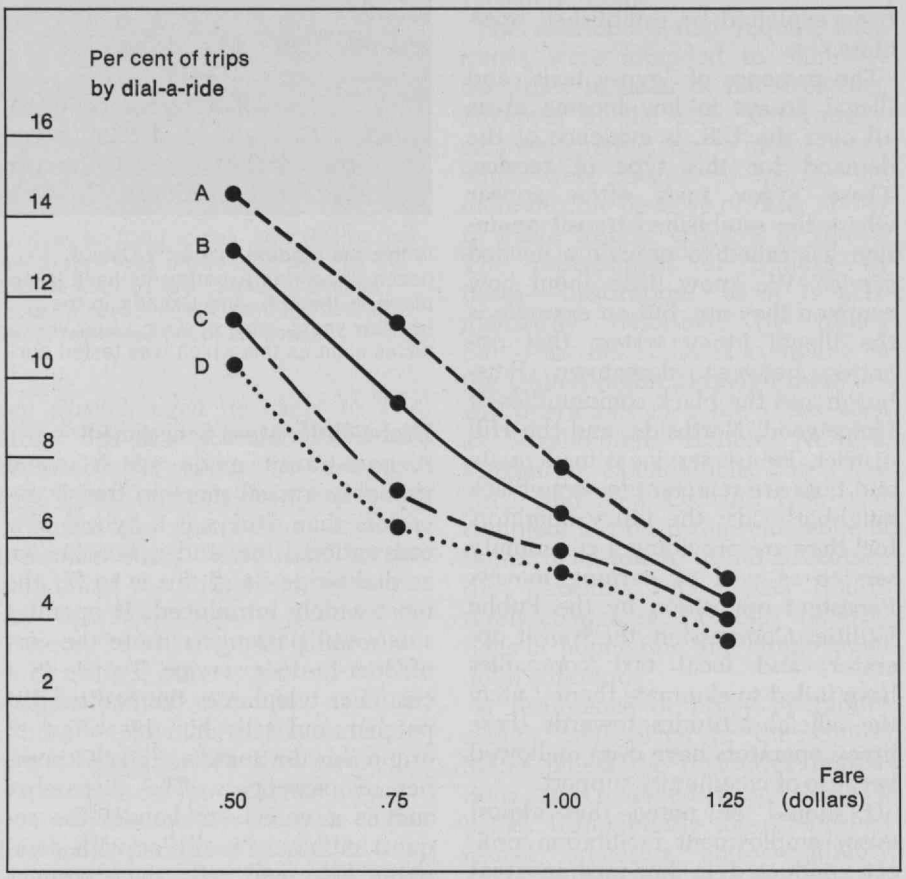


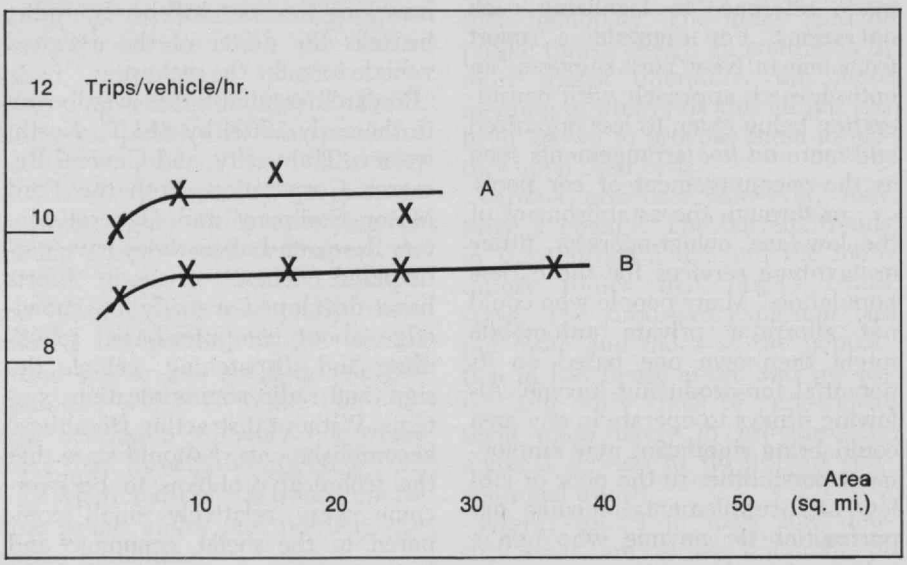
Analyses of dial-a-ride systems make it clear that their economics are highly sensitive to cost factors, fares (subsidized or not), quality of service, and density of demand.

The chart **above** shows the relationship of cost to density of demand for several urban transportation modes. Dial-a-ride is shown to be the least expensive transportation system for a range from 20 to 100 demands/sq.mi./hr.; above that number conventional buses, operating on fixed routes, are the preferred system, and below 20 demands/sq. mi./hr. the individualized service of a taxi is least expensive.

In its market studies of dial-a-ride **(right),** Ford Motor Co. determined that up to 15 per cent of riders might be diverted to a dial-a-ride system whose fare was 50 cents and whose passengers were assured waiting times of no more than 15 mins. and times in transit of no more than twice those of private automobiles (curve A). Patronage would slip if waiting times rose to 25 mins. (B) or if times en route increased to three times those of a private automobile (C—15-min. waiting time; D—25-min. waiting time).

Meanwhile, M.I.T. studies **(below),** assuming dial-a-ride travel times no more than 2.5 times those of private automobiles, show that the size of its service area affects but little the number of trips which a dial-a-ride might make per hour. The two curves show the trips per vehicle per hour with 40 demands/sq. mi./hr. (A) and 25 demands/sq. mi./hr. (B).





In a city of 200,000 in which 1 per cent of all trips are now made by public transit, a dial-a-ride system might capture 3 to 15 per cent of all trips with capital costs of less than $1.25 per trip.

vice, might capture 3 to 15 times that, even when offered at a premium fare.

The cost and fares are crucial in the success of a dial-a-ride system. Fares that cover full operating and capital costs will probably range between $.50 and $1.25 for an average trip. The closer the service offered resembles a taxi operation the higher will be the fares, while lower fares are possible if longer total trip times are acceptable to the passengers.

Already in Service in Many Variations

Over a dozen dial-a-ride experiments have taken place over the past few years in the United States and Canada, providing a variety of services in a variety of circumstances. In the suburban communities of Haddonfield, New Jersey, and Bay Ridges, Ontario, D.A.R. systems are feeding riders to commuter railroads; one in Regina, Saskatchewan, feeds fixed-route buses heading downtown. Ann Arbor, Michigan, Batavia, New York, and Columbia, Maryland, have D.A.R. systems that provide direct services from residential areas to downtown and to more dispersed business areas. The question of whether dial-a-ride can substantially increase the personal mobility of the poor, the elderly, and the handicapped is being addressed by systems in Model Cities neighborhoods in Columbus, Ohio, in Detroit, Michigan, and in Buffalo, New York.

These systems have been sponsored by varying combinations of the federal, state, and local governments with a good deal of input from private industry. Their costs, acceptance, and overall success has also varied: some unqualifiedly successful, others teaching us by their mistakes. We have had enough experience now to conclude a few things about their use.

In a number of different contexts, D.A.R. systems have demonstrated that they can attract new patronage for transit. In Bay Ridges, Ontario, for example, the operation has drawn a significant number of passengers away from the auto. This is a many-to-one service: from many homes to one destination, the train station. Dial-a-ride vehicles meet every Toronto commuter train at the Bay Ridges station. These modified Ford Econoline vans feed the train with 55 per cent of its riders from this station: before the D.A.R. began, 62 per cent of them arrived by auto, and now only 40 per cent do so.

The first year of operation of the Haddonfield, N.J., demonstration, has been much less successful than the Bay Ridges feeder service. The service in Haddonfield provides twice the number of vehicle-hours as Bay Ridges, but attracts about the same number of daily passengers. However, ridership continues to grow as the service area is expanded. In addition to feeding, the Haddonfield station of the rail rapid transit line between Lindenwold, N.J., and downtown Philadelphia, Pa., this D.A.R. system also serves a number of major activity centers and a general residential area within Haddonfield. This is the only major federally funded demonstration of dial-a-ride technology that is currently in operation. The demonstration, jointly financed by the Urban Mass Transportation Administration and to a lesser extent by the New Jersey Department of Transportation, is the only one to have U.M.T.A.'s support.

Dial-a-ride systems have so far attracted only a small number of the total journeys made in their areas: some 2-4 per cent in Haddonfield, 3 per cent in Bay Ridges, 1-2 per cent in Batavia, 2 per cent in Ann Arbor, and 6-7 per cent—the best—in Regina. This results in low demand densities which causes productivity, the number of trips per vehicle-hour, to also be low. The initial studies predicted, and the operating experience has confirmed, that good service becomes very expensive if demands average fewer than 20/sq. mi./hr. These demonstrations have produced perhaps half that.

And Financially Reasonable

Experimental D.A.R. operations have, nonetheless, proven themselves to be more cost-effective than conventional transit. The first evidence of this came in Mansfield, Ohio, where the Ford Motor Co. was the driving force behind a modified dial-a-ride experiment. On request and for a premium fare, the driver of a fixed-route loop would deviate from the regular route for doorstep pickup and dropoff. When this new capability was added to the fixed-route service, the line reduced its operating deficit substantially. The transit company regarded it as successful and requested funds for more vehicles. Unfortunately, the operator and city council were unable to agree on expanded service, so the experiment was discontinued after one year.

The most successful financial results are being achieved in Batavia, New York. Local capital has funded the "B-Line" which operates in an area formerly served by a fixed-route service with low ridership. The dial-a-ride line offers subscription service for work and school trips during peak hours and dial-a-ride pack-

A myriad of institutional and political hurdles—including the historically conservative attitudes of public transit management and perhaps of transit labor as well—stand between successful para-transit experiments and widespread use of such innovations as dial-a-ride.

age delivery service during off-peak hours. With a variety of services and a vigorous, imaginative marketing program, the "B-Line" has increased ridership by 30 per cent. Wages are low, so the revenues now cover the line's operating costs.

Because of its low operating costs, Batavia is a special case. No other D.A.R. experiment has yet managed to earn money. This certainly does not mean we should call the experiments failures. Dial-a-ride should not be expected to be profitable when public transit registers increasing deficits yearly. More reasonable measures of success are whether D.A.R. can reverse declining transit patronage trends and entice new transit passengers. In each of the previously mentioned experiments auto passengers have been diverted to transit and the new service has lost less money.

We must consider measures of success besides profit. A community may be willing to absorb a deficit if there are substantial benefits in terms of increased mobility and opportunities for residents. Columbus, Ohio, is the site of a D.A.R. system whose deficit is absorbed by the local Model Cities Agency. This system, which has also had substantial technical assistance from the Transportation Research and Planning Office of Ford Motor Co., is basically a route-deviation scheme. A dispatcher instructs drivers to deviate from a basic route to make doorstep pickups and deliveries. The reported ridership of 400 per day indicates an enthusiastic response by the neighborhood residents. Most of the riders do not have access to an automobile for the trips they make by dial-a-ride, so they have gained considerable personal mobility.

Virtually every urban area is proposing or actually implementing dial-a-ride or a similar demand-responsive system to similarly improve the mobility of those citizens who are transit dependent: the elderly, the handicapped, and the poor. A D.A.R. service is already provided free to senior citizens in an inner-city area by Model Cities Jitney Transportation of Buffalo, N.Y.

The Communities' Response: Enthusiastic

In fact, many of the dial-a-ride demonstrations have been so well accepted that their operators have dramatically increased the size of the systems. Such a one is in Ann Arbor, Michigan, although it takes a large subsidy to meet the difference between its expenses and revenues. Both citizens and city officials are enthusiastic and optimistic about the system, and they recently decided by a referendum to make it city-wide. The new service will combine doorstep service with express bus services among major activity centers. There will be fast transfer between neighborhood D.A.R. vehicles and express buses. The system in Regina also enjoys unqualified taxpayer and city council support, and Regina officials plan to make it city-wide by 1976.

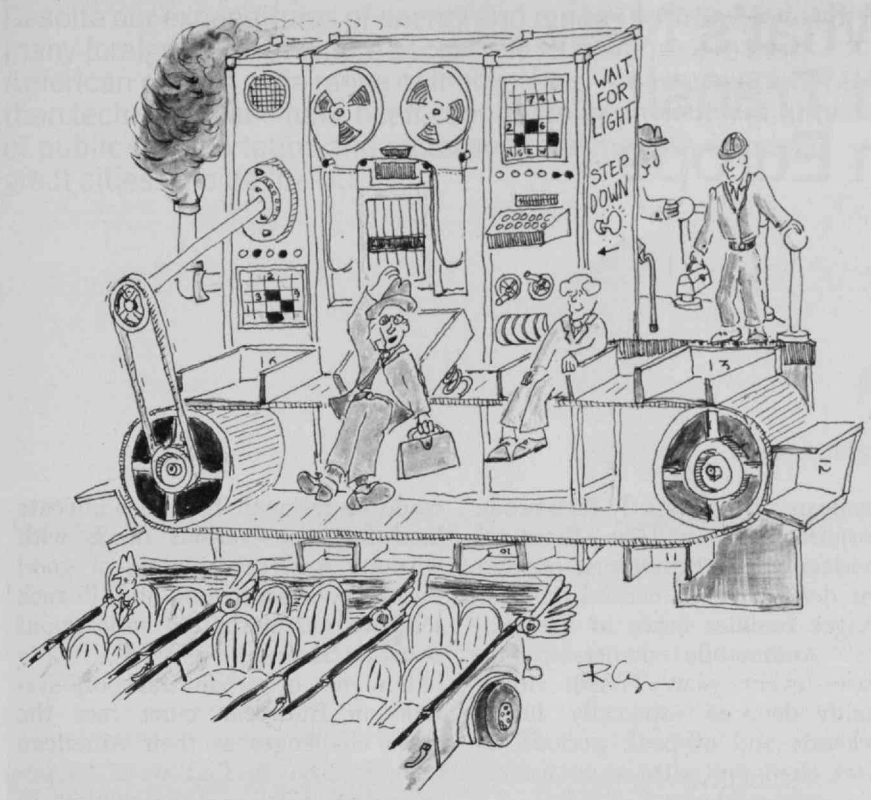
The dial-a-ride system in Haddonfield has already been expanded in area of coverage and number of buses. And the success of the Bay Ridges demonstration in Ontario has prompted Toronto to plan for a system that will provide feeder service to some of its express buses. This new 30-vehicle system will be considerably larger than the usual demonstration size of 5 to 12 vehicles.

D.A.R. is not one service but a concept of demand-responsive transportation. A full range of D.A.R. services should be used to accommodate the different needs of patrons. The more efficient subscription services taking people to or from only one place are highly productive for the journey to work during peak-hours, while the same system could accommodate many origins and destinations during the off-peak hours. The best example of this concept is in Batavia where a range of services is provided including the latter during off-peak hours, subscription work trip service during peak hours, and a school and college trip service which is also operated on a subscription basis.

The Batavia project's managers stress the importance of marketing techniques. They have frequent newspaper reports on the plans and progress of their system and they send direct mail ads to potential users. Ads in local newspapers, D.A.R. lapel buttons, and handouts are also used to tell patrons that they are offering a new, attractive personalized service.

Early studies predicted that problems might come from taxi operators, because D.A.R.'s door-to-door service and low price would lure away many taxi patrons. Two taxi companies have, in fact, sued the system in Ann Arbor, Mich., on the grounds that it was providing unfair competition. The suit was dismissed on the grounds that the service was useful as well as distinct and different.

Instead of viewing dial-a-ride as a threat, some enlightened taxi owners have incorporated some of its concepts in the operations. The owner of a Davenport, Iowa, cab company has attracted more than 1,000 passengers per weekday with what is basically a D.A.R. system in spite of the relatively high average fare of



A basic principle of all dial-a-bus systems is "many-to-one"—a single focal point of departures or arrivals yields traffic to or from a number of local destinations to which service is personalized. (Drawing: Robert Caspi)

$1.10 per trip. His drivers earn approximately $3.00/hr. which is no less than they would earn under a conventional taxi operation. The low managerial and dispatching cost and low labor cost enable this system to be financially profitable. This should be compared to the high overhead and dispatching costs and high labor rates of unionized transit workers in the bus-based D.A.R. operations.

The Urban Mass Transportation has funded a good deal of D.A.R. research and one small demonstration project, the one in Haddonfield. It has been less enthusiastic about funding the large-scale demonstrations which were suggested by the researchers. Limited demonstration budgets and congressional restraints led to the decision to start the Haddonfield experiment: many researchers felt this to be an overly conservative approach. While the Haddonfield demonstration has not yet attracted the ridership that was originally predicted, there has been a constant growth in patronage that has not yet seemed to level off. The Haddonfield operators are optimistic that future phases of the demonstration, introducing computer routing, will produce more enthusiasm.

Until the Haddonfield experiment produced positive results U.M.T.A. was restrained by a senate subcommittee from funding any additional dial-a-ride demonstrations. However, the D.A.R. systems already mentioned have arisen independently. The Ford Motor Co., through its Transportation Research and Planning Office, has catalyzed many projects. Transportation consultants and university researchers should also be given credit for suggesting to many communities that D.A.R. is a reasonably cost-effective alternative to conventional transit and for helping each community design the service that makes the most sense for them.

U.M.T.A., more cautious earlier, has recently become optimistic as good results from dial-a-ride systems seemed likely, and it has chosen more aggressive policy towards funding new projects.

Part two of the Haddonfield experiment, which has already begun, calls for an expansion of the service area, an increase in the number of vehicles and the provision for computer assignment of customers to vehicles—the first major demonstration of a computer-dispatched system. U.M.T.A. is also developing a medium capacity computer and communication system that would be capable of routing and scheduling approximately 1,500 demands per hour. They plan to complete the development of this system in 1973 and expect to fund a much more extensive demonstration than Haddonfield in a medium-size city during 1974.

Surprisingly little investigation has been made of the operational experience of taxi operators like the one in Davenport, Iowa, who offer D.A.R. type services. To fill this gap U.M.T.A. has funded an in-depth study of the shared taxi system in Davenport and another one in Hicksville, Long Island. There is a potential of high payoff from research into this other paratransit mode. This University of Tennessee investigation of shared taxis could provide direction to many other taxi fleet owners who want to provide dial-a-ride services.

U.M.T.A. is becoming interested in the whole range of para-transit modes. A comprehensive study of experience with para-transit is being conducted for U.M.T.A. by the Urban Institute. Comparative analysis of the whole spectrum of para-transit modes will be one product of this study. It will also include recommendations on future demonstrations of para-transit and could be a forerunner of a new approach to providing more demand-responsive transportation for our urban areas.

Inquiries have been made into the myriad of institutional and political hurdles faced by D.A.R. One of the largest that must be overcome if dial-a-ride is to fulfill its potential concerns the choice of the system operator. It was pointed out by Ford and M.I.T. researchers that the capabilities of those who operate new D.A.R. systems will have a profound effect in the systems' chances of success. The historical review of jitneys suggests that traditional transit operators are conservative toward innovations. Labor may well be equally conservative. Yet, unless modern marketing and management methods are used, any new public transportation system will be no more successful than conventional ones.

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What's New in Transit in Europe

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European cities presently face urban transport problems like those of American cities. Residential populations decline in the central cities as younger families move to the suburbs. Automobile ownership increases every year. Transit riding steadily declines, especially during weekends and off-peak periods, to reflect changing patterns in recreational and social travel.

Transportation facilities there as here accommodate the demands of the automobile. New regional highways connecting major European cities have been built or are being planned. The high-speed motorways that have been constructed include geometric design standards, safety provisions, highway lighting, and pedestrian crossings that at least equal those built in this country. An extensive road system to serve the increase in recreational and summer traffic among Scandinavia, the Netherlands, Bavaria, Italy and Spain and Northern Germany is being considered.

In responding to the changes the automobile has brought, European planners and policymakers have recognized that the central city is the cultural, institutional, commercial, recreational, and economic focus of its region. Accordingly, they have not let investments in the public transport serving it deteriorate. The auto's deleterious side effects—pollution, excessive land requirements, and property destruction—are being mitigated by investments in public transport, so that mobility within major cities is being preserved. And so are the cities.

European countries have no highway trust funds. Instead, they have dependable ways of financing public transportation, which has meant that planning and implementation could be rational. They also allocate land for their various needs with wisdom. And this context of good public policies, plans, and finance schemes has permitted innovations in urban transport.

Managers of urban transport systems in European cities face the same challenges as their American counterparts: to find ways to improve the use of existing facilities, to develop management techniques that will reduce costs and increase patronage, to design and build new systems that are comfortable and convenient, and to incorporate the results of research and new technology into present operations and future plans.

Obviously, experiences in one city are not directly transferable to another, and the cultural, historical, and economic differences between continents further widen the gap. Yet, Europe's experiences can shed light on innovations in urban transport that appear to have promise and in general on how cities can cope with the motor age.

The improvement of urban transit in Europe involves either incremental changes in existing systems or substantial investments in new systems.

Incremental changes are appropriate in cities that already have networks of transit routes and vehicles, and modest and inexpensive changes in service can often bring about dramatic changes in ridership. The effect on transit ridership of marketing and promotional programs depends heavily upon the quality of the transit service: cities that have reasonably attractive systems benefit well from innovative marketing techniques. Two such are Hamburg, Germany, and Gothenburg, Sweden.

Despite our expenditures of energy and money for transportation, many foreign cities are more accessible to more people than American ones. A wide range of innovations—more governmental than technological—have been adopted to improve the quality of public transportation and increase urban mobility in many great cities outside the U.S.

Following the destruction of World War II, Rotterdam has built a short Metro and confirmed a commitment to urban transit for the central city. Without subsidy from the national government, the city has undertaken—in addition to the Metro—a substantial upgrading of surface tramlines and feeder services; many of the former have exclusive rights of way. This approach to urban transit, writes the author, is typical of that in many European countries—and in Montreal: "The success of these systems is not measured by the difference between costs and revenues; the systems are seen as necessary to keep cities strong and lively. . . . European cities have decided that public transport is vital for the support of community objectives." (Photo: Ewing Galloway)

Must the automobile dominate the urban landscape? Rotterdam's Lynbaan, (below) a new shopping area in the city center facing the City Hall, contrasts with Paris' Champs Elysees (above); but in many European cities (including Paris), writes the author, public transportation is being developed so effectively that cities are not endangered by urban freeways and parking lots. (Photos: Ewing Galloway)

On the other hand, large changes and new systems are also being planned and built, just as in the United States where only a few cities have extensive transit systems but many are either building them or considering doing so. Practically every major European city is constructing new rapid transit lines. In Montreal, which we consider a European city, and Rotterdam, the beginnings of a total system are now in operation. London, Paris, Munich, and Stockholm have major new lines that sometimes extend their urban metro systems to serve airports, sports arenas, and new communities.

We shall look at examples of each approach and at a new town, Runcorn, which has good transportation and land use plans intended to reduce auto travel demands.

We must remember that the passenger regards transit service not in terms of mode or technology but in terms of attributes. He doesn't care if the vehicle is a bus, tram, or train, or if it runs on steel wheels, rubber tires, or air. He cares about comfort and quiet, frequent service, reasonable travel times, reasonable costs, and convenience of access. European systems are based largely on conventional technology, primarily rail rapid transit, tram cars, and buses. The Hamburg story is a case in point. European planners view technology as the least important variable in transit; service counts more.

Hamburg: Innovation through Cooperation

Public transportation in Hamburg before 1965 was provided by eight private companies. The largest, Hamburger Hochbahn Aktiengesellschaft (H.H.A.), operated about 50 miles of rapid transit, 60 miles

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of tramway, and 400 miles of bus routes, and carried 70 per cent of the city's passengers. The German Federal Railway (D.B.) operated 96 miles of suburban rail, 44 miles of them electrified, and 26 miles of suburban bus routes; it carried 25 per cent of the passengers. Port ferries were the responsibility of another company that owned 48 boats and covered 55 route miles. Three small railroad companies operated suburban service over 30 route miles, and two other companies furnished approximately 300 route miles of suburban and interurban bus service. Together these systems covered some 1,100 route miles, 2,500 vehicles and 2,300 stations with rapid transit, suburban railway, tramways, bus, express bus, and ferries.

Hamburg, the second largest city in Germany, contains 1.9 million persons, its metropolitan region about 2.4 million. Although transit had been fostered through a policy of restricted parking, Hamburg had the familiar pattern of declining patronage, increasing car ownership, and suburbanization. Furthermore, the eight transit companies did not coordinate their services; they often competed. Each company had separate fares; there were no provisions for transferring between different carriers and modes of travel. A long and circuitous route would often save money: the direct route cost more. In some cases companies even provided parallel services. Clearly, the use of Hamburg transit was threatened, not only by changing demand patterns, but by this lack of coordination among carriers.

In 1965 the eight companies agreed to form a transport federation, known as the Hamburger Verkehrsverbund (H.V.V.) to coordinate all transportation services in the region. The H.V.V. is not a takeover of private companies into a large public agency, but a separate management agency supported by the partner companies. The individual firms continue to provide transit service and are responsible for maintaining schedules and equipment, for furnishing labor and facilities, and for all matters pertaining to the daily operations of their routes, vehicles, and fixed facilities. The H.V.V.'s tasks include traffic research and planning for the system's transfer points, transit routes, time-tables, joint-fare schedules, and station locations, and promotion, advertising, and public relations.

The partners agreed to distribute receipts so that none should be relatively financially worse off than before and so that there would be a financial incentive to each partner to be efficient in its operations. Revenues are allotted among partners according to each partner's revenue-to-cost ratio in the base year and the number and unit costs of route miles, seat miles, and vehicles provided by that partner for the revenue period.

The organizational agreement is a simple one. It separates management from daily operations and has created incentives for improvements in both areas. The H.V.V. began operation in 1967 under the joint direction of a representative from the H.H.A. and the D.B. It has a staff of about 60, and is funded by about 2 per cent of the gross revenues.

Several improvements were instituted immediately in the coordination of services and fares. The H.V.V. adopted the idea that rapid transit lines would serve the central city radially, and bus routes would act as feeders to the suburban stations. Tangential routes or areas not adequately served by rapid transit are served by bus and tram. Revised schedules, good transfer connections, and coordinated fares have improved overall travel times, lowered fares in most cases, and reduced operating costs through more efficient service. Monthly and seasonal tickets have simplified fare collection and reduced transfer times.

The new system is comprehensive and efficient. And so, in 1969, for the first time in over a decade, transit ridership increased—by 3 per cent. It continued to do so in 1970 and 1971 and then leveled off as demand was fulfilled. Encouraged, the H.V.V. is now working on more ways to improve transit services.

A no-barrier entry to rapid transit stations, for example, reduced fare collection costs and simplified entrance for people with tickets or passes. Some revenue has of course been lost, but spot checks indicate that only 2 or 3 per cent of passengers have not paid. The honor system is enforced by a "flying squad" of inspectors who can levy a stiff fine to violators on the spot—a legal situation that is not permissible, for example, in London where due process must be observed.

The H.V.V. sells weekly and monthly passes at substantial savings, and travelers with credit accounts can be billed automatically each month. The convenience of buying a monthly pass by mail, as public utility bills are paid, has become very popular. Additional marketing techniques are reduced fares on special shopping days, lotteries using ticket stub numbers, and children's contests. The H.V.V. has widely distributed complete timetables of all bus, tram, and rapid

transit routes and simple, easy-to-read system maps. Publicity about new services, route changes, and other related information is furnished directly to the communities involved, and queries or complaints are well attended to by the H.V.V. staff. These methods have built for the system a generally good reputation.

Hamburg's lesson for us is not in technology or new systems, but in the new ways of using mundane and often old bus and rapid transit networks. Having achieved such good results with cooperation, Hamburg is now extending its system in several ways. It is building extensive park-and-ride facilities financed by center city parking meter revenues; it is providing dial-a-ride or taxi services to rapid transit stations at night; it is building new railways underground; it is monitoring bus flows by computer and installing television surveillance for security at bus and transit interchange points.

Gothenburg: Restricting Autos in the Central City

Gothenburg, Sweden, has put a traffic restraint scheme in its center that gives us another illustration of incremental modifications that substantially improve both transit ridership and the accessibility and environmental quality of the downtown. Improvements and innovations in urban rapid transit are usually cited for cities of over one million people, but Gothenburg has fewer than 500,000, so the results are especially significant for medium-size cities in the United States.

Gothenburg has an extensive system of trams and buses—some 70 route miles of tramway and 250 route miles of buses. The radial tramways, carrying about 75 per cent of all passengers, are the backbone of transit service for the city. Though much of the population has been moving into the suburbs, the center of Gothenburg contains the principal commercial and employment activities, with some 40,000 places of work and several major department stores.

Early in the 1960s a group drawn from various city agencies, including the police, planning, traffic, and transit departments, was asked for a strategy to improve the environment of the central business district and increase access to it easily and cheaply. Solutions that required high construction costs and long lead times, such as parking structures, new rapid transit lines, or major highway additions, were excluded from consideration.

As early as 1961, the city authorities had thought about having part of the downtown traffic-free, and the planning group began to study the idea in earnest.

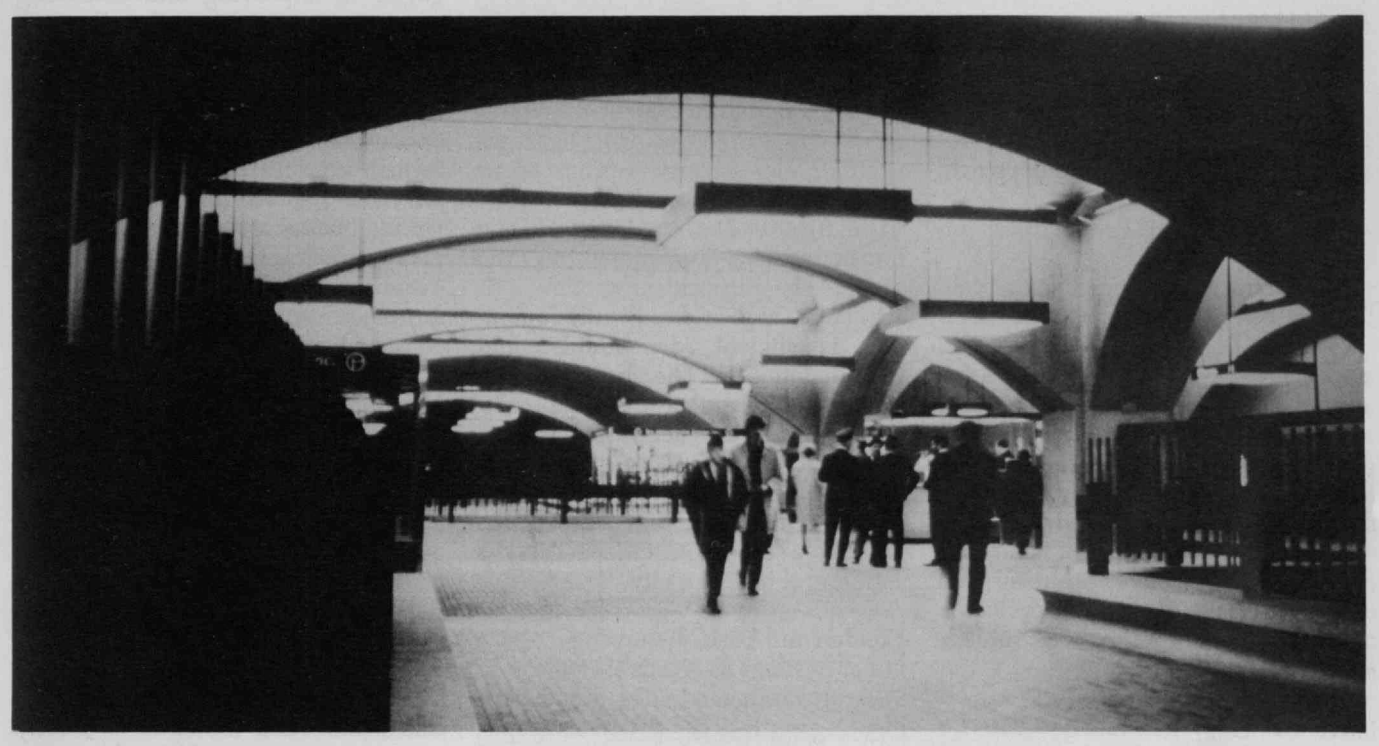
Although its objective was to reduce auto travel into the central area, the group discarded as impractical plans that required a complete banning of cars from the city because of legal problems and the requirements for additional central city distribution facilities. Instead, the group hoped to restrict traffic movements within the core area but not prohibit access.

The planners divided the core area into five zones, each delineated by major streets. An auto cannot travel between zones and can only leave the core area from the zone that it entered: the traffic through the downtown area is eliminated and conflicts among autos, pedestrians, and tramway traffic within the central area are reduced. Several of the streets that act as zone boundaries were also designated as bus and tramway routes; they are transit rights-of-way free of automobiles. To accommodate through traffic, the planners developed a system of ring roads.

The traffic restraint scheme was introduced in August, 1970. With the exception of a few reconstructions of intersections, the changes were accomplished simply by painting lines, erecting directional signs, and installing barriers. The public was apprised of the plan through an extensive program that included radio announcements and the publication of pamphlets, maps, and newspaper stories, and the change happened over night. The entire project cost $220,000, of which 80 per cent went to rebuild intersections.

The traffic restraint scheme has been highly successful. Aside from the impressive accomplishment by dedicated and decisive public officials of a radically new plan for an historic central city, several tangible results have been measured. Public reaction has been positive, with the exception of taxi drivers who must follow the rules and not cross zones. (Gothenburg officials have strictly resisted pressures against exceptions, feeling that if one group gains a variance others will seek one and the scheme will eventually erode.) Measurements of the effects on air pollution and noise indicate them to be good. For example, carbon monoxide measurements on the main shopping street were reduced from 60 ppm. in peak hours to 5 ppm. or less, noise levels from 75 to 72 decibels. Retail merchants are happy. Travel times are shorter.

The easy mobility within the core has shown up the deficiencies in other parts of the city. So the plan-



Montreal's shiny new subway is highly regarded by transportation experts and architects alike. It was designed, built, and financed entirely by the City of Montreal, the work commencing in May, 1962, and ending in 1967. The 16-mile system cost just $213.7 million, completely equipped. Each of the system's 26 stations is individually designed by a different architect, each with its own character; this is the Place Bonaventure arcade, which includes a complex of shops and businesses designed so that the traveller is hardly aware of the transition from subway to shopping.

ners are now seeing about expanding the traffic restraint scheme to improve tramway lines in outlying areas by extending the private rights-of-way outward.

Montreal: An Underground Metro of Function and Beauty

Several cities in Europe and Canada have built underground rapid transit lines in the past decade. Each city has hoped, by major action, to strengthen the central area of the city and to reduce traffic congestion. Perhaps the most exciting is Montreal's Metro.

Montreal began to build its Metro in 1962; it was in use by 1965. Its architecture is innovative; its operation is efficient; and it clearly demonstrates a good relationship between rapid transit and land use. The Metro system is approximately 16 miles long, has 26 stations, and cost $214 million. It has three lines that operate independently; they connect at one central station. This central station is adjacent to many miles of underground shopping malls, and the traveler would be unaware, were it not for turnstiles, that he has left the station for the complex of shops and businesses. The whole Montreal system demonstrates a pleasing continuity among stations and commercial and residential activities.

Each station has its own character and motif. Each was designed by a different architect who was charged to make the station compatible with its neighborhood. Some of them, for example, use concrete in new ways, and in general their corridors and platforms feel spacious. Since the Metro system was opened, the concept of distinctive design is being adopted by other systems to replace

the drab "white tile" stations seen in older systems. The Metro is clean and free of grafitti—the community is proud of its attractive facility. Vandalism is rare and quickly resolved when it does occur, partly because the citizen in Montreal is permitted to make arrests for it on the spot.

The Metro was financed completely by the city. It does not depend on provincial or federal support. It is a sort of grid system: all lines are operated separately and connect at a transfer point. The grid system is better than an interconnected branch pattern, for the system can be completed in increments; a mix of technologies and equipment can be used; operational problems are minimized; the level of service is maintained as new lines are added; and outlying areas can be covered as comprehensively as the core.

The Metro system has generated a corridor of concentrated commercial activity. The Metro Commission cooperates well with the private sector, and it works closely with existing commercial activities and planned developments.

The planners quite practically selected a rubber-tired vehicle. The vehicle technology is similar to that used in the Paris Metro, and had been tested for a period of ten years prior to its adoption in Montreal. Since the system's operating characteristics were known, little research and development was necessary, and the Metro could be built quickly.

The grades of the system are generally steep, in order to follow the rock layers—conditions for which a rubber-tired vehicle, able to negotiate higher grades than steel wheels on steel rails, is cheaper.

Headways between trains are only 2 to 3 minutes during peak and off-peak hours and station dwell times as low as five seconds. Some buses in Montreal parallel the Metro because certain short trips are better served by surface transit. But connections at outlying Metro stations are provided and transfers are free.

The Montreal Metro is an urban transit system unequaled in the world. The physical environment is attractive and exciting; the operation is efficient, dependable, and well maintained. The success of the Metro demonstrates that the creative efforts of engineering, planning, architecture, and design combined with excellent operating policies can result in a system that attracts the patronage of all its citizens and is an integral part of a city.

London and Paris: Renewing Older Systems as Needs Change

Several European cities are experimenting with new system concepts, both as demonstration projects and under daily operating conditions. London, whose public transport is necessary for the city to function, is trying to reduce labor costs by automating the operation of its underground system and by converting to one-man bus operations where feasible. London added the 25-mile-long Victoria Line in 1968. Except for an attendant who opens and closes doors and presses a button to start the train, the operation is fully automated. This line also has automatic fare collection. Automated turnstiles and ticket vending machines will probably be installed throughout the underground system. Paris is continuing to install bus-only lanes to improve surface flow—successfully—and to rehabilitate and renew older underground lines and stations.

Predictably, the main activities in both London and Paris are adding and extending lines, modernizing stations, developing labor-saving techniques, and improving operations. Both cities combine very old and very new technology. Paris has a fully developed grid network of 16 lines covering 110 route miles, and its most recent addition is the new regional express, a suburban rail service that has been extended into the core of the city from the west and will eventually link up with the eastern suburban rail services as well as connecting with the Metro.

Because both cities are actively engaged in improving and extending services, transit planners and operators come from all over the world to London and Paris to learn about their management, construction, and operation. Their transport agencies furnish consulting services to cities all over the world, including the United States. The London transport people claim to have made every possible mistake and before anyone else, since they have been constructing and operating transit systems for over 130 years.

Outside of Paris, near Orleans, a test of the air-cushion principle has been under way since 1969: a full-scale 80-passenger, turbine-driven vehicle runs faster than 160 mph. over an 11.2-mile test track. Earlier tests with a half-scale vehicle in 1965 demonstrated that such a vehicle could manage to go 200 mph. The French are also experimenting with a 40-seat vehicle propelled by a linear induction motor at a nearby test site in Gometz.

The test program has been sufficiently successful to warrant building a tracked air cushion line connecting the La Defense station of the Paris Region express with a new satellite community, Clergy, some 15 miles outside of Paris. The line, which will have one intermediate station, should be completed by 1976.

The Aerotrain developers believe the system to cost less to build than conventional rail rapid transit, to be quieter, more efficient in its use of energy, simpler, faster, and to have as good properties of acceleration, deceleration and braking. The extensive tests carried out under private auspices during the past five years have supported these claims.

This achievement is remarkable because both the federal and local governments have adopted the Aero-

train rather than a conventional train and thus have allowed a test of the system in revenue service. U.S. experience with new systems has been that they are given lip service and half-hearted funding for less than complete demonstrations, and the major commitments necessary for full-scale testing do not come either because local officials are reluctant to commit public funds for projects involving risk and uncertainty or because national politics inhibits the funding of projects large enough to be important and successful.

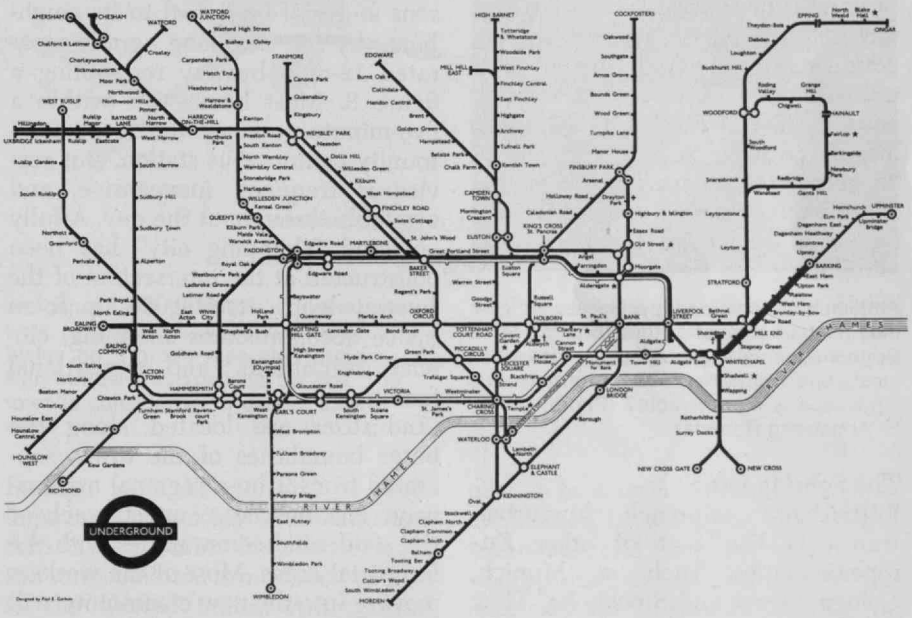
Rotterdam: New Metro

Rotterdam, with a population of 800,000, also has a new metro line. The line replaces a congested river crossing with an underwater tunnel to connect an important residential community to the south with the city center that was rebuilt after World War II's destruction. It has kept its riders, while Rotterdam's other services have lost some of theirs.

The line is to be extended by 1974, from eight to 11 miles long and from eight to 13 stations. As Montreal's Metro, the line was financed without monies from the national government, although a second new line connecting the central area with an eastern suburb, soon to begin, will receive some.

The Rotterdam Metro is largely elevated: its stations permit bus and tram interchanges and parking for autos and bicycles. One station has parking for 900 autos, and this attracts riders who would ordinarily drive. Although the system is steel on steel, it is relatively quiet, as its designers hoped—as quiet now as when it opened. Concrete ties and specially designed connectors with energy absorbing material between rail sections have greatly dampened noise. Although most of the line is above ground and near residential neighborhoods, its structure, noise, and vibration affect its environment only slightly.

Rotterdam also has extensive tram and bus lines. The city hopes to increase the number of miles of tram line that have exclusive rights-of-way. It plans to use "pre-metro" approach that upgrades the service capability of these street railways until full-scale metro lines are required.



London is an example of a major European city which seeks to capitalize upon its already-well-developed transportation system. Its 250 miles of subways (above) contrast sharply with its street and highway system; instead of developing the latter, London seeks to improve the efficiency of public transportation with automated operations. Trains on the new Victoria Line are fully automatic, with only one attendant to see that doors are secured before starting the train, and there is automatic fare collection and ticket vending.

Accommodations for bicycles are as much a part of public transportation in Copenhagen as are parking garages in most American cities. Whose urban landscape is more livable? (Photo: H. Armstrong Roberts)

The Subsidy Issue

Rotterdam's approach to urban transit is like that of other European cities, such as Munich, Cologne, Oslo, and Stockholm. They confirmed a commitment to urban transit for the central city and then went about constructing new underground lines as appropriate, upgrading tramlines, and improving the transfer and feeder services to metro stations.

In each case the commitment has required that communities and national governments furnish a subsidy for both operating and capital cost. The success of these systems is not measured by the balance between costs and revenues; the systems are seen as necessary to keep the cities strong and lively.

Whether the communities and governments will maintain their commitments to transit construction and their allocations of funds among competing modes and services as deficits grow, will be a matter of interest. But it is clear even now that European cities have decided that public transport is vital for the support of community objectives, and that it will prevail through the foreseeable future.

Runcorn: A City Free of Automobiles

Whether planning can control the use of automobiles is being tested in a unique new English town called Runcorn. The basic concept for Runcorn, which is being built around an older community of 26,000 near Liverpool and will eventually house about 100,000 people, is that if public transport is planned as part of the community, its citizens will rely less on auto travel.

The plan for Runcorn is for a series of individual residential communities. Each will have about 8,000 persons and will be linked to its neighbors by a two-lane grade-separated 12-mile busway resembling a figure 8. Most homes are within a five-minute walk of the local community center—bus station. Bus service is frequent, inexpensive, and available throughout the day. A fully enclosed "shopping city" has been constructed at the intersection of the busway loops; its 500,000 sq. ft. of space accommodates shopping, cinema, restaurants, and recreational facilities.

Industries are located along the outer boundaries of the town, separated from it by a regional expressway. The busway connects each of the residential communities with the industrial areas. Most of the workers moving into the new community will probably be employed locally.

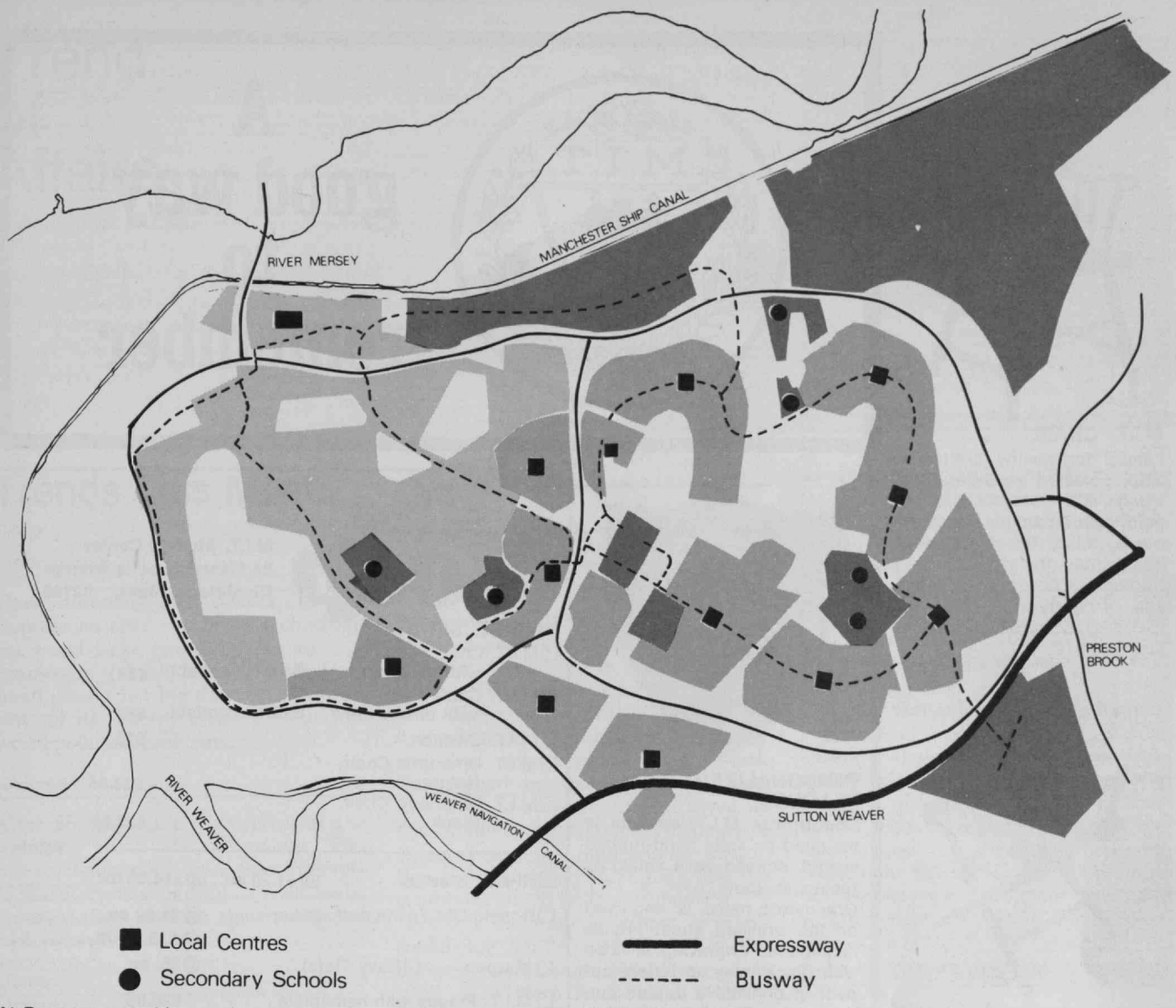
Each residential area within Runcorn contains separate community facilities such as a primary school, convenience shops, medical and dental offices, libraries, and meeting rooms focused around the busway station and easily accessible by pleasant footpaths. The bus can furnish almost a door-to-door service, whether to work or to shop, whereas the route by auto is circuitous and the parking sites distant. Runcorn's planners studied alternative transport modes including computer-controlled automated systems, trams, and monorails. They found a clear economic advantage for buses on a grade-separated roadway.

Runcorn's central shopping city is completed, and several of the residential communities have been opened and are connected by seven miles of the busway.

The town represents a unique experiment in community planning, and, although the results will not be evaluated for many years, it has attracted the attention of transportation planners throughout the world. The concept is a sound one and those elements that have been completed appear to be functioning well. The town is realizing its objectives: to mitigate the environmental effects of the auto and to reduce the need for travel. The national government has helped by its substantial support of the transportation network. Since bus service has been available from the outset, and a major shopping facility is in operation, residents have not required second cars. The balance between public and private transport will probably be maintained as planned. If the experiment is successful it will serve as a model for other new communities seeking to enhance the quality of urban life.

Lessons

The preceding descriptions of activity and innovations in urban transport in Europe illustrate the range of solutions that have been attempted recently to improve the quality of public transportation and increase urban mobility. In spite of traffic congestion, Europe has many cities that are exciting and attractive: witness the number of Americans who visit them each year. It appears that the European center city is not obsolete simply because the ubiquity of the auto makes entire regions easily accessible. Rather, the Europeans have tried to maintain and enhance cities by improving accessibility to city centers through better public transport and by enforcing accessibility within the center with streets reserved for pedestrians, shopping malls, street underpasses with escalator connections, and bicycle paths. Commercial, shopping, and working activities continue to be the principal functions of the center city, and the strength and stability that such concentration brings have not been destroyed by urban freeways and parking lots.



At Runcorn, near Liverpool, a new town composed of a series of individual communities is being built around an existing town of 26,000. It will be a city in which no resident needs an automobile; most residences will be within a five-minute walk of a bus station served by vehicles on a grade-separated busway with frequent, inexpensive service. The town is considered "a unique experiment in community planning," writes the author, among whose objectives are "to mitigate the environmental effects of the auto and to reduce the need for travel."

The central city, however, is not the only focus for transit innovations. European cities use government subsidies for maintenance and construction in other ways as well. Several provide special services for the handicapped and reduced fares for the elderly and the young. Others improve transfer connections between modes, park and ride facilities, pedestrian connections, fare collection, vehicle operation, television surveillance of stations, uniform fare structures, and public information programs.

The preparation and implementation of programs that are so beneficial to the city demonstrate good coordination among professional groups and disciplines. The professional transportation planner and transit operator in Europe has been familiar with the city and its problems longer than his American counterpart, as mobility between cities of the same country is much lower than in the United States. Antagonisms between central city and suburb are fewer. As a result the professional community is stable and committed to carrying out long-term projects. The planners appreciate their cities' cultural and historical backgrounds better than their U.S. counterparts; such an appreciation is a casualty of greater mobility. Policy decisions are the responsibility of elected officials, but implementation is the task of the specialist, so politics are not a major impediment to implementation. Citizens do not participate in planning to the extent that programs are curtailed. Whatever the reason, there does not appear to be a serious problem in communication between the citizen, the technician, and the policymaker.

Europeans accept innovation as necessary for the continued life of public transport, so new ideas and techniques are carefully evaluated and adopted when appropriate. Accordingly, many innovations are already in operation that have not yet been tried in the United States. Because European cities have maintained and expanded their investments in transit they are better prepared to take advantage of still newer ideas. Thus, concepts now in research demonstration in the United States—for example, personal rapid transit and dial-a-bus—may, should they prove feasible, be accepted and implemented earlier in Europe.

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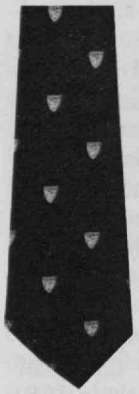

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TR-73

Trend of Affairs

Trends This Month

PERSPECTIVES

Science: A Spiritual Exercise, Too

Nicolaus Copernicus was born five hundred years ago this year, and with him the second great age of science began. The first, beginning in Ionia and Athens, lasted five hundred years: it encompassed the birth of Christianity and died several centuries afterward. The second has now nearly attained that Grecian measure, and to honor its first architect the National Academy of Sciences and the Smithsonian Institution met this spring to enquire into the conditions which let science flourish.

Perhaps the most important is man's confidence that he can find out how the universe works and that doing so is good. Why were Euclid and Ptolemy Greek rather than Chinese?, asked Stephen E. Toulmin, Professor of Humanities at the University of California—Santa Cruz. The Chinese did not have that belief, nor the tradition of examining their fundamental ideas about nature.

Gerard Holton, Professor of Physics at the University of Santa Clara, wondered about the immediate conditions that encourage science: he remembered that during the time Johannes Kepler was doing mathematics in Linz, the town was beseiged and soldiers were quartered in Kepler's apartment in the town hall. Night and day the soldiers came in and out. In those circumstances, Kepler raised his eyes to heaven and began to study the stars.

A question that continued to appear during the symposium was how rational analysis relates to intuition and suggestion. "Scientists now tend to disclaim their creativity," Dr. Holton continued, "and believe themselves to be hard inductive thinkers." But Albert Einstein believed there was no necessary logical bridge between phenomena and the theoretical explanation of them. He talked of intuitive jumps, guided by strong presupposition drawn from observations. And he asked of a theory, Dr. Holton continued, only that it not contradict facts and that it be simple.

Copernicus wrote that the "world is designed as a beautiful temple" and of the "loving care that one must give to these beautiful things." Dr. Holton commends this spirituality. For from it, he senses, comes the energy to continue to discover.

Werner Heisenberg spoke—from experience—of another requisite: the discussion that friendship nourishes among scientists. The great friendship between Einstein and Max Planck helped them to describe quantum mechanics and the theory of relativity. Neils Bohr invited Erwin Schrödinger to Copenhagen to talk about waves and within weeks they—and Dr. Heisenberg—"elucidated the principles of wave mechanics and the uncertainty principle."

But the success of scientific questing depends not on personal ideals and relationships alone; it depends also upon the society around the effort. Science must have thrust upon it questions to answer, to keep it vital and healthy. There is now, Dr. Heisenberg said, no lack of them. By contrast, he believes art is trying to work with themes that are no longer fresh.

The questions put to science still challenge it. At the turn of the century physicist A. A. Michaelson told us we had solved the major problems of physics; only refining was wanted. Then Dr. Heisenberg's generation produced its theories, and, Stanley Wheeler, Professor of Physics at the University of Birmingham, told the symposium, although the theory of relativity is the most unifying one physics has ever had, it is not the last theory. "It is, Neils Bohr said, 'not crazy enough.' "

Owen Gingerich, an astronomer from Harvard, reminded the group of one practical condition—financial support. Copernicus was a canon at the Cathedral of Warmia; his church duties were few and supported his astronomy. Tycho Brahe's establishment cost the king of Denmark a ton of gold, and the

Hale telescopes in California cost Andrew Carnegie a like amount.

Science has another practical side—practicality as a motive for doing it. A scientist wants to see that the world works as he thinks it does—he gets into applications more for that than for profit, Dr. Heisenberg remarked. He describes as the cash value of his conception that it works in explaining nature and that it fits what he sees. "He needs confirmation from nature that he has understood her."

The Grecian age of science ended in confusions: of the need for and nature of scientific exploration; of the difference between science and technology; of too much specialization in subsciences; of the relationship between science and the humanistic and spiritual efforts of mankind. Men turned to the humanities for their questions and to the eastern religions. Several of the participants worried that the same turning was happening now. But perhaps science needs only to affirm its faith in its own spiritualism—in the creativity and intuition that Einstein recognized.—*J.K.*

Let Art Grace a Technological World

Modern man, having created for himself "a world with no meaningful direction," spends his existence "racing in little steel caskets from nowhere to nowhere." He needs a sense of scale, a relation to the wholeness of his environment.

Though we have great physical power, says Gyorgy Kepes, Director of M.I.T.'s Center for Advanced Visual Studies, we live in constant turmoil and frustration, in a "tremendously distorted" relationship with our environment.

Must it be so?

Perhaps not, for "in some great periods of history there have been moments when men have lived in a crescendo of interdependence between themselves and their world, . . . seeing in it a broad unification of everything that makes life worthwhile." Delphi in ancient Greece seems to have been such a place, where there existed an "equal partnership" between man and nature.

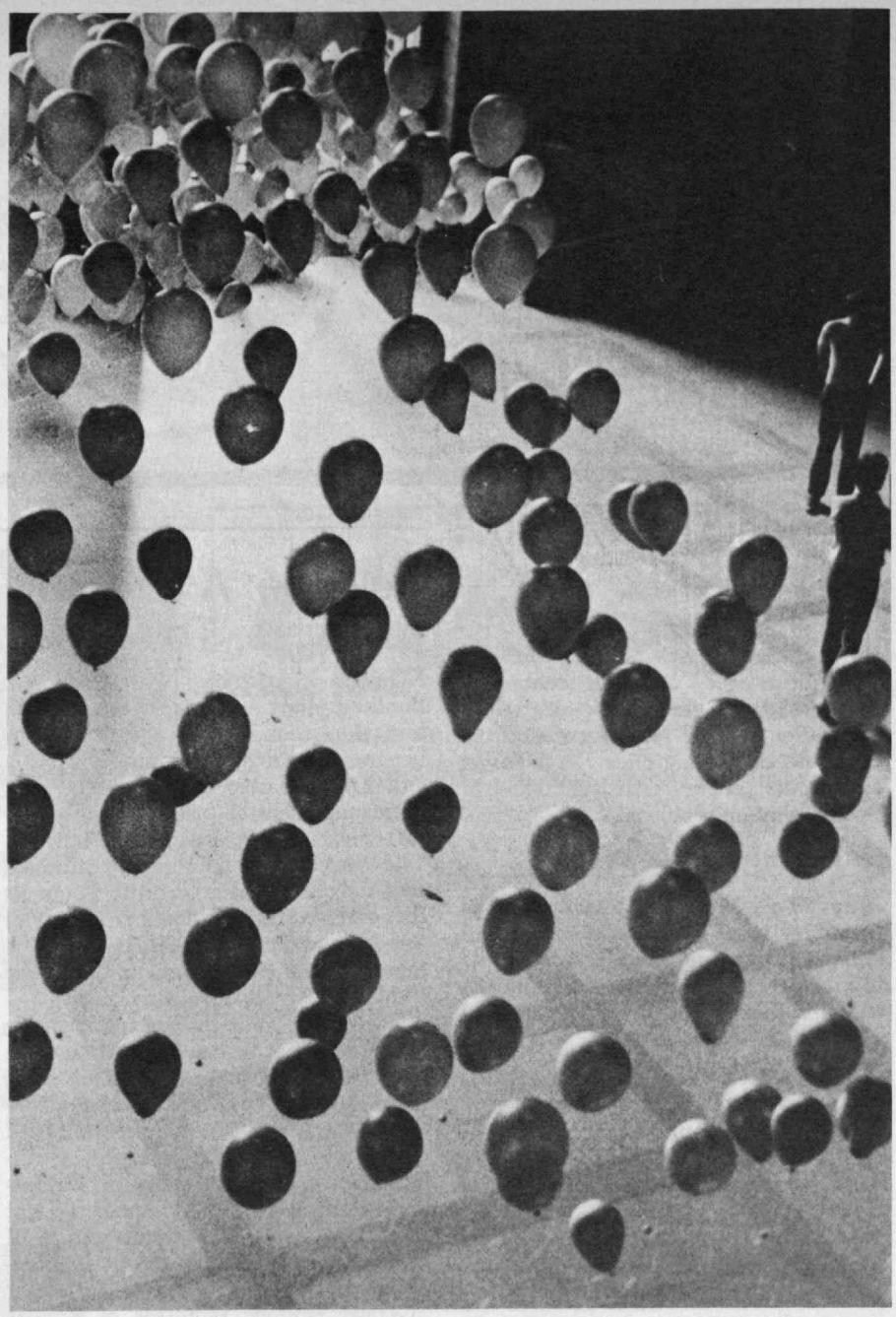
Professor Kepes, who has been at M.I.T. as an artist among engineers for nearly 30 years, is no antagonist of technology. He simply believes that art brings quality and vision to a world preoccupied by quantity.

Look at London in the time of Constable, Shelley, or Turner—men living in "torturous cubbyholes in which one could not find himself." But look at a Constable painting and sense its "freedom of space and motion." So it is that artists "project what is missing in their own lives, . . . dreaming of a world which is richer and more human," Professor Kepes says.

Look at New York, or any great city, today—"an exploded world which has lost its sense of scale," in which people lead "chopped-up existences unaware of what surrounds them."

Yet today's world is a tremendously exciting one with which artists are "jubilant," full of "rich images" and vistas "tremendously expanded" by science and its tools. So it is that Professor Kepes and the Fellows in his Center for Advanced Visual Studies seek to create "forms which give everyone a share in the joy of life." The goal is not to merge art and technology, though tools, materials, and even images of modern technology have important roles. The real goal is to find a "new art which gives life a civic meaning . . . and people a chance to play with nature."

In this sense, Professor Kepes told a meeting of Boston-area M.I.T. alumni this winter, art is far more than an artist expressing his ego. It is "man's effort to shape his life and consciousness."—*J.M.*



"Forms which give everyone a share in the joy of life" is a goal of his Center for Advanced Visual Studies, says M.I.T. Professor Gyorgy Kepes. An example is this project by ten students of the Center's Otto Piene, who devised this "floating carpet" of silvered balloons in the main lobby of M.I.T. this spring. This kind of art, thinks Professor Kepes, "gives people a chance to play with nature."

Innovation: Don't Look at Home

Why does the U.S. persist in its efforts to solve automotive pollution problems by attaching peripheral gadgets—"Christmas tree engineering"—to the internal combustion engine?

Not because no better alternatives are in sight.

Because, rather, the Environmental Protection Agency has chosen to rely too heavily on the automotive industry for the technology on which it will base its regulation of that industry. And the automotive business, like many large industries in the U.S. which are primarily concerned with production and marketing, does not manage to attract innovative technical entrepreneurs and engineers, thinks Richard S. Morse, Senior Lecturer in M.I.T.'s Sloan School of Management.

Indeed, Professor Morse told the Subcommittees on Environment and Science of the Senate Commerce Committee this spring, "there is ample precedent to suggest that innovative technological ideas are usually generated outside" of the industry to which they are apparently most applicable. Among his examples: the Polaroid camera, Kodachrome film, the ball point pen, catalytic cracking of petroleum, penicillin, xerography. . . .

The automotive industry provides its share of examples, too—power steering, the low-emission Honda engine, Stirling engine developments in Europe, and the Japanese and German Wankel.

Professor Morse thinks the picture is consistent for "major industries which are primarily concerned with problems of production, marketing, and return on investment." As a case in point, the automobile industry is simply unable to "respond rapidly to technological change. Because of the long lead time between conception and the commercial introduction of a new development, most automobile manufacturers are not attractive employers for innovative, technical entrepreneurs who wish to see tangible results of their ideas in the marketplace at an early date." The result, he said, is that "certain segments of the automotive industry are not fully informed about advanced technology and innovative thinking found in our more progressive, research-oriented industries and smaller companies."

Mr. Morse speaks from experience—and with feeling; he is Chairman of Scientific Energy Systems Corp. (formerly Steam Engine Systems Corp.), and his small company expects to install a 150-h.p. Rankine-cycle (steam) engine in a 1974 Plymouth Fury (*see* Technology Review *for January, 1972, p. 68*). It will operate power steering, power brakes, and air conditioning, and its emissions will be well within the 1976 E.P.A. limits, Mr. Morse told the Senate Subcommittee.—*J.M.*

Russia on Energy: Complacent . . . .

The Union of Soviety Socialist Republics does not expect to have a shortage of energy, Academician Valeriy Popkov told an audience at M.I.T this spring. The laboratory chief of the Krzhizhanovskiy Power Institute in Moscow, he toured the United States this spring with Academician Valentn Shteinberg, director of the Institute of History at the Latvian Academy of Sciences, under an exchange of scientists sponsored by the American Association for the Advancement of Science and its counterpart in the U.S.S.R.

His country, Mr. Popkov said, has great reserves of fossil fuels—54 per cent of the world's coal, 40 per cent of its gas, 37 per cent of its oil, 61 per cent of its peat. Its rivers give the Soviet Union 25 per cent of the world's hydroelectric power. "Thus well-provided with principal power sources," he said, it will not experience a "catastrophic shortage of fuel until other power sources as atomic power plants or even thermonuclear fusion are sufficiently developed."

The U.S.S.R. does have problems of supply, however, he continued, because its resources are mostly east of the Urals and its people mostly west. The nuclear plants it has now are in the east; it has great lengths of pipelines and transmission cables. In fact, Russia has planned to have a nationwide power grid almost from the time it began electrification. This has meant building cables of high capacity long before they were needed, Mr. Popkov said, but it also means that Russia can do with 5-9 per cent less in overall capacity. The U.S.S.R. presently transmits mainly with A.C. lines, but it is building D.C. transmission lines of 800 kv. and 750 Mw. and it projects one from Siberia to the west some 2414 km. long and carrying up to 6 million kw. on a 1500 kv. cable. It has even bigger plans for the lines after that.

The Soviet Union has built five nuclear plants, some water cooled, some of a water-graphite channel type, with capacities of under 500 Mw. It's future plants will be breeders, for it too must conserve uranium 235: in fact, it already has at work several plants equipped to breed nuclear fuel. Mr. Popkov reported that the Soviet Union also uses the waste heat from its steam plants to heat both water and homes in some 800 towns and villages—an idea that is still revolutionary and believed to be impractical here. His country continues its research on new sources of energy and methods of conversion: the Tokamak machine for plasma fusion and the magnetohydrodynamic generator.

Of the outcome of the research? Mr. Popkov turned to the French: "Qui vivra, verra—Who will be living, will see."—*J.K.*

. . . and on the Environment: Concern

Academician Valentn Shteinberg (*see above*) described attitudes and perceptions of his own and of the Russian people towards man's relationship to his earth that are as hopeful and concerned as ours. In the words of physicist Pyotr Kapitsa, he said, "We are all living at present in one large communal flight. The planet earth is the house of all mankind, and the principles of humanity should rule all decisions about its use."

The Soviet Union has made a series of laws in the past few years—and the people have supported them—dealing with the preservation of human health and the health of the environment. Moscow's air is cleaner, because some 200 industries have moved outside its city limits. A city of 800,000 on the Volga will by 1980 completely purify its waste water and recirculate most of it within the city.

"The scientific and technical revolution need not," Mr. Shteinberg continued, "significantly increase pollution; in certain conditions pollution can even be fully avoided. . . . The experience of the U.S.S.R. is a good example, as are those of the other socialist states."

But the resolutions and actions of the Soviet Union by itself are not enough; "the problems require solutions on a global scale." His country, he reported, is anxious to develop international cooperation, and to peacefully coexist with nations of different economic systems. "It does not wish to interfere with the internal matters of other states, but to cooperate."

Russia has held a series of discussions recently about environmental problems based on the experiences of several nations, Mr. Shteinberg said. From them, these objectives emerged: to develop, internationally, "suitable norms of the natural world as bases for the implementation of regulations and activities among nations and individuals," a means of arbitration of conflicts, and the enforcement of decisions by international agencies equipped with the best in monitoring equipment; the development of international cooperation in the use of technical developments and in the financing of international programs.—*J.K.*

"I knew it was important," recalled Walter H. Brattain when asked by an I.E.E.E. member this spring about his view of the transistor when the Bell Laboratories team of which he was a member first demonstrated its feasibility. Indeed, on the way home that night in 1947 he told his car pool that he had just taken part "in the most important experiment in my life." Twenty-four hours later he had to swear them to secrecy. Here are the three Nobel laureates who shared the prize for the transistor as they were reunited at the I.E.E.E. 1973 convention: (left to right) William Shockley, John Bardeen, and Dr. Brattain; they are receiving special gold medals donated by Seymour Schweber (right). (Photo: I.E.E.E.)

SOLID STATE

Transistors After 25 Years—and More

A quarter of a century after their discovery, there is still nothing conventional about transistors—about the processes of invention and development that brought solid-state devices to their present omnipotence in communication and computation, about the problems they present to today's manufacturers and users, about the issues they propose for the future.

By the beginning of World War II it was clear that solid-state materials had unusual properties. But when Bell Telephone Laboratories assembled a solid-state group after the War—during which everyone had been distracted from work on such esoteric questions—Mervin J. Kelly and his colleagues in the management of Bell Labs knew only that the then-anomalous effects had to be understood, whether or not they proved to be useful.

Did the idea of making a solid-state amplifier really occur to William Shockley, who went to Bell Labs' solid-state group from M.I.T. in 1936? "I thought it wouldn't work," Dr. Shockley told members of the Institute of Electrical and Electronics Engineers this spring—"but it was so important that we had to try."

With Dr. Shockley on the I.E.E.E. platform were his two principal colleagues in the subsequent transistor inventions, Professor John Bardeen of the University of Illinois and Dr. Walter H. Brattain, now at Whitman College; the three shared the Nobel Prize in physics in 1956, and the I.E.E.E. session was an emotional tribute to them from a profession which has been almost completely transformed in less than a quarter century by their work. They are "the giants on whose shoulders we stand," said Myron J. Tribus, General Manager of Research and Engineering for Xerox Corp., in making the introductions.

The job might not have been done if it had been treated as a fundamental research problem—simply a search for understanding. True, success depended on more fundamental understanding of the chemistry and physics of semiconductors. But applications to communications were very much in mind. Dr. Brattain recalled an early discussion with Dr. Kelly about how slow, cumbersome relays would have to come out of telephone systems. Neither mentioned it, but Dr. Brattain is sure that both thought of the possibility that solid-state devices would do the job.

Bell Labs' solid-state group was a close-knit team. Bell Labs turned them loose after specifying only the area in which they were to work. But the group stayed together. Their notebooks are full of references to luncheon conversations, formal and informal conferences. Whenever anyone made a discovery they all came together to discuss its meaning—and where to go next. These conversations were "the most important part of the effort;" Dr. Brattain said it was "one of the greatest research teams I ever worked with."

Dr. Shockley thinks their understanding of the transistor effect was gained as much by "floundering around" as by any scientific inspiration—a "creative failure" methodology by which one capitalizes as much from negative as from positive results.

What of the solid state industry today? Still an enigma to Paul Beroza, Vice President of Motorola, Inc., who despite his own company's success in the field remains "profoundly and humbly impressed" by the delicate technological processes involved.

Those who have succeeded in the business of making semiconductors, he told I.E.E.E. members, have been those who came into it without the illusions of previous components manufacturing experience. If a company worried too much about proprietary protection for its own innovations, he said, it simply could not respond to the demands for tremendous growth—a $1.3 billion industry (1972) has grown from less than $1 million in just 12 years.

Economic growth and technological change will continue. Speeds of circuits will be limited only by the speed of electrons in the devices themselves—a limit which is not far away, said Dr. Beroza. As speed increases, so can the complexity of solid-state devices and machines.

Can we learn to manage this new industry? The question is not frivolous; the economics and management of

work, will take to the air as a sustainer on Aug. 19.

A device called a transistor, which has several applications in radio where a vacuum tube ordinarily is employed, was demonstrated for the first time yesterday at Bell Telephone Laboratories, 463 West Street, where it was invented.

The device was demonstrated in a radio receiver, which contained none of the conventional tubes. It also was shown in a telephone system and in a television unit controlled by a receiver on a lower floor. In each case the transistor was employed as an amplifier, although it is claimed that it also can be used as an oscillator in that it will create and send radio waves.

In the shape of a small metal cylinder about a half-inch long, the transistor contains no vacuum, grid, plate or glass envelope to keep the air away. Its action is instantaneous, there being no warm-up delay since no heat is developed as in a vacuum tube.

The working parts of the device consist solely of two fine wires that run down to a pinhead of solid semi-conductive material soldered to a metal base. The substance on the metal base amplifies the current carried to it by one wire and the other wire carries away the amplified current.

This inconspicuous notice in the "radio" column was all the *New York Times* could say about the transistor on July 1, 1948. But 25 years later at least 1 billion transistor radios are in use in the world—changing alike the lives of Arab herdsman and teen-age American beachgoers.

rapidly advancing transistor-based technology "is foreign to the experience and instinct of many economists, businessmen, and politicians," thinks Dr. Beroza. "The future of the U.S. in the information revolution depends on our ability to educate people" who will understand these special needs.

Dr. Tribus, presiding at the session, agreed—and added his own strongly worded, pessimistic footnote: "My concern is that in government today there seems to be no infrastructure which understands the conditions for scientific and technological progress."—*J.M.*

Transistors in 1980: How Many Billion?

After 25 years of revolutionary progress in solid-state electronics (*see above*), what do you do for an encore?

More of the same, thinks Robert N. Noyce, President and Director of Intel Corp.

Dr. Noyce, speaking in a symposium this spring commemorating the M.I.T. Electrical Engineering Department's move into its new Fairchild Building, does not forecast another transistor. His confidence in the future is not based on such a major new technological discontinuity; it is based instead on the expanding markets for solid-state devices and integrated circuits—and on the realizable potential for their further improvement.

To explain what he means, Dr. Noyce shows what he calls a "learning curve"—displaying, for example, how the unit cost of an integrated circuit element has come down as production experience has gone up. The ratio, he thinks, is about 10 to 1: "every time we make 100 times as many units the cost drops by a factor of 10." Integrated circuit memories, for example, now cost between 0.3 and 3 cents per bit; by 1980 they may cost 0.05 cents.

Another trend on which Dr. Noyce bases his optimism: the complexity that can be achieved in integrated circuits—the number of elements that can be combined into a single device, and the number of functions it can perform—has doubled every year since the first such circuits were built a decade ago, and he foresees "no reason for this trend to stop."

But statistics like these do not alone justify Dr. Noyce's irrepressible optimism. A major characteristic of the semiconductor industry, he told his audience, has been rapid innovation and rapid economic growth. For some lucky entrepreneurs this process has yielded high profits—enough of them, and enough profits, to keep competition keen and price tags coming down, and to maintain constant pressure for new innovation. It is a self-fulfilling cycle, he says, which works ever-better and ever-faster in an expanding market.

The computer market—first the big, time-shared machines, then the minicomputers, and soon the microcomputers with a whole logic system in one or two integrated circuits—has been barely big enough (2 billion gates—transistors or calculating elements—in 1972) to sustain this cycle. But think about this: 5 million pocket-size solid-state calculators were made in 1972, and each used 500 gates, a total of 2.5 billion gates. More calculating elements went into calculators than computers last year. The calculator market will double each year for at least the next two, thinks Dr. Noyce, and he cheerfully looks for a market for 10 billion calculating elements for these products alone by 1974.

What about the automotive market? One minicomputer per car (to control carburetion and accessories, to monitor coolant and oil levels, among other things) might require 2,000 calculating elements. Multiply that by 10 million cars . . . Or think about the watch market: there are 200 transistors in a new "electronic" watch; 200 million watches will be sold in the U.S. in 1975; if half of them are electronic, that's a market for 20 billion calculating elements.

And then there's the matter of giving a telephone instrument enough logic so that it can, for example, automatically keep trying to reach numbers whose lines were busy when first called. Dr. Noyce thinks this is "well within the range of possibility," and it will represent a market for 100 billion calculating elements.

Is there an ultimate limit to the growth of solid-state, integrated circuit devices? Perhaps, admitted Dr. Noyce; but "not in this decade . . ."—*J.M.*

ENERGY

What Comes After a Petroleum Orgy?

History will record the 20th century as "an incredible orgy of burning gas and petroleum." In the space of hardly more than 100 years, man will have discovered, exploited, and largely depleted these unique energy resources.

Already we see the end before us, and this is one component of today's "energy crisis." It is also the principal reason for our desperate need of a national energy policy, thinks Representative Mike McCormack (Dem.—Wash.), who is the only scientist in the Congress and who, as Chairman of the Energy Subcommittee of the House Committee on Science and Astronautics, is assuming the role of "Mr. Energy" in the House of Representatives.

In spite of great interest in energy in Congress, formulation by Congress of a national energy policy is probably impossible; that task belongs to the Executive, said Mr. McCormack at an M.I.T. seminar this spring. But here are some elements of such a policy, as seen in Mr. McCormack's office:

☐ There must be accommodation between environmental protection and energy demand; it is "self-defeating," thinks Mr. McCormack, "to allow blind emotionalism to prevent the development of new energy resources"—by which he meant, he said, the Alaska pipeline, new petroleum refineries, nuclear reactors, and others. And no one state or region should be able to impose its energy burden on others by outlawing the facilities which must be built to provide the energy it needs.

☐ With domestic supplies meeting less and less of our needs, the U.S. should establish a 90-day petroleum reserve and, under the same policy, should be certain that some central power gen-

erating stations can promptly convert their operation from oil and/or gas to coal. These measures, thinks Representative McCormack, would be cheaper than any other option open to us in case our oil imports are cut off—and would moderate "the profoundly disturbing implications of our dependence on imports" of petroleum.

□ Though a major, mission-oriented, Apollo-style effort is not a singular answer to the "energy crisis," such a research and development effort on new energy resources is a major need. This would include continued work by the Atomic Energy Commission on breeder reactors, an $11.4 million increase in the A.E.C.'s budget for fusion research in 1973-74, and "massive research and development" on all reasonable alternative sources of energy—geothermal, solar, synthetic fuels; as well as basic research on fuel cells, and energy transmission, storage, and conservation. Considering the nation's immense coal reserves, Representative McCormack is "appalled" that there has been no broad research and development program on coal gasification or liquefaction. Indeed, he finds the "lack of an organized research and development program on energy, especially fossil fuels, deplorable and shocking."

How can a national energy policy be managed? Only from the White House, thinks Representative McCormack, where a single authority can command attention from the many different agencies of the Executive Branch which are now involved—the A.E.C., the Department of the Interior, the Environmental Protection Agency, and others. But President Nixon's present approach, which assigns energy responsibilities to several members of his staff, would be inadequate even if not weakened by the problems of Watergate. What's needed is a single focus of authority—an expert in the energy business—who is not distracted from it by other responsibilities.

"The First Encouragement on Coal"

M.I.T.'s Hoyt C. Hottel, Professor of Chemical Engineering Emeritus who was seated in the audience, found himself "enormously heartened" by Representative McCormack's strong plea for action on synthetic fuels from coal. "You're the first national figure who's ever been encouraging to me on the coal problem," who seems to understand "what a grand big resource we have in coal."

The time has come, Mr. McCormack agreed. By next year funding for both breeder and fusion programs should be secure, and we can indeed turn to coal gasification and liquefaction. The cost of a national commitment to put such plants "on the line" by 1980 would be "a tiny fraction of the cost of putting a man on the moon—perhaps no more than the cost of a large aircraft carrier."

What about energy conservation? asked a member of Mr. McCormack's audience. Another important subject, he agreed; but it is not central in resolving whatever we mean by the "energy crisis." Mass transportation, for example: it has limited leverage on energy conservation because most cities, having been developed without dependence on mass transit, can hardly adapt to it today.

In the long range, said Representative McCormack, one can only think about very much larger changes in our ways of life—for example, redeployment of our population into communities where personal transportation is not required. This kind of thing will become a "fact of life," he said. "We live in a dream world which we take for granted—but which is in fact only a brief interval in history."—*J.M.*

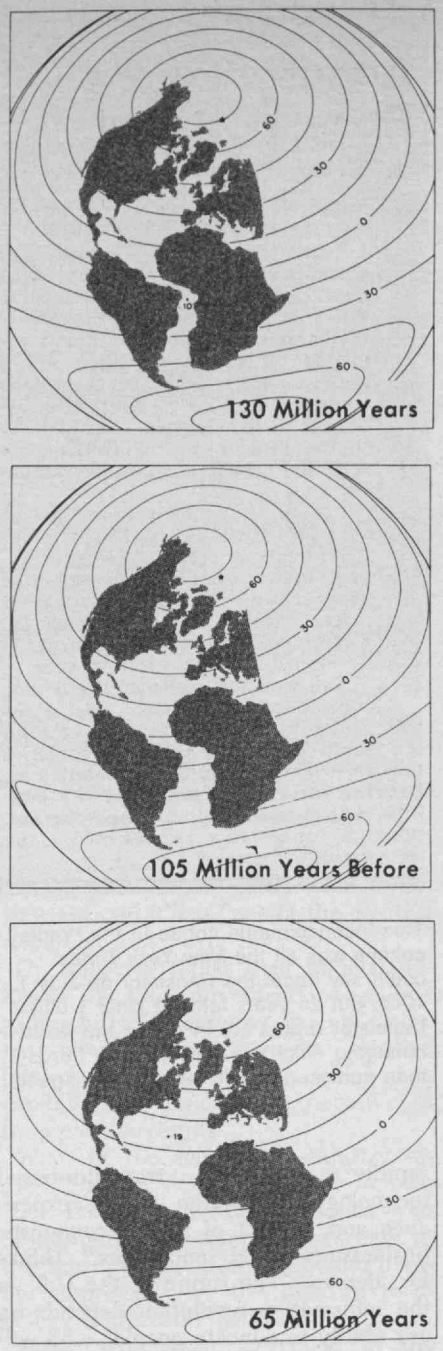
LAND AND SEA

The Great Flood on the Ocean Floor

The cores of sediments that the ocean drilling programs bring back from the Atlantic are filled with the fossils of tiny shellfish and plankton and other worms. But the sediments in the central Atlantic change abruptly about 40 to 50 million years ago. No more hard-shelled animals can be found; in their place are the fossils of sea urchins and sea cucumbers and other soft-shelled fishes. Why? Charles Hollister, a geologist from Woods Hole Oceanographic Institution thinks the cause of change was an undersea flood.

He explained to the *Review*: if the theory is right that the continents were once joined and are slowly drifting apart on huge crustal plates, Greenland and Iceland and Scandinavia were bumped up tightly against each other until a few hundred million years ago. Then they slowly began to separate, and among the channels formed were a few from the Norwegian Sea to the Atlantic. Some 50 million years ago, frigid Arctic water, denser than warmer stuff, began to flow downhill and along the Atlantic's bottom. The channels widened until 2^{10} millions of cubic meters of water flowed down them each second, to meet a like flood coming north from the Antarctic, released at about the same time by the same processes. After both floods washed to the equator, a stretch of the Atlantic's deep center, some two to five miles wide, was covered by up to 900 meters of chilling water.

It was perhaps 2°C., colder by 5-10°C. than the rest of that on the bottom. At about 4°C., the hard shells of clams and snails and other animals dissolve. They have never since lived in that part of the floor. The soft-shelled creatures, like soft-shelled crabs and bivalves and the urchins and cucumbers that could survive the icy cold moved in, perhaps along with the floods from the polar extremes. They live there still, for the Norwegian Sea, Gulf-stream-fed, continues to flood the Atlantic floor.—*J.K.*



This map shows how close Iceland, Greenland, and Scandinavia were 100 million years ago—and, where, when they began to drift apart, icy Arctic waters coursed through the channels as far south as the Caribbean. *(Illustration: Science News© 1972, Science Service Inc., Washington, D.C.)*

Arthritis: Look in Bone, not Joint

Mammalian joints are superbly engineered, and their lubrication mechanisms are so effective that joints do not "wear out" from overuse or overload, no matter how prolonged or intensive. Osteoarthritis, a degenerative disease of joints that affects some 40 million Americans, arises not in the joint itself; the trouble is in the associated bony structures, which become stiff and so fail to absorb the shocks of such repeated activities as walking, dancing, throwing, or digging.

This conclusion, which results from applications of mechanical and metallurgical research techniques to orthopedics, suggests that osteoarthritis may be simply "the natural outcome of the biological response to repeated impulse loadings." It is a new understanding which may make possible "a whole new armamentarium of therapeutic measures" on which orthopedists are now at work.

The relationship of repeated stresses to the appearance—usually late in life—of osteoarthritis is well known. Pneumatic drill operators frequently develop arthritis of elbows and shoulders, ballet dancers of their feet. But the mechanism was not understood until a presentation early this year to the American Academy of Orthopedic Surgeons by Dr. Eric L. Radin, Assistant Professor of Orthopedic Surgery at Harvard Medical School; Igor L. Paul, Associate Professor of Mechanical Engineering at M.I.T.; and Robert M. Rose, Associate Professor of Metallurgy and Materials Science at M.I.T.

The new research makes it clear that the basic problem leading to osteoarthritis from repetitive impulse loading involves not the joint but the so-called subchondral bone, relatively soft material behind the joint which acts to absorb shocks and thus protect the joint. Cartilage, though it seems soft, elastic, and shock-absorbent, does not have this role.

Repeated shocks to the subchondral bone cause microfractures, and when these heal the subchondral bone loses its shock-absorbing ability. Only when this happens does cartilage degeneration result from the higher peak stresses of unabsorbed shocks.

The work represents an interesting melding of medical and engineering research techniques. The group arrived at their hypothesis using experimental equipment developed by Professor Paul at M.I.T. With the equipment, knee joints of rabbits and guinea pigs were subjected to repeated impulsive loads (equivalent to their body weights of between eight and 10 lbs.) at a rate of 60 times per minute for one hour daily.

Professor Rose analyzed the subchondral bone tissues by means of techniques which metallurgists have used for half a century in making three-dimensional studies of materials.

Early studies in the project led the workers to dismiss joint lubrication problems as a source of osteoarthritis; they soon concluded, in fact, that mammalian joints are "superbly lubricated." For example, the coefficients of friction which they measured in a dog's ankle are "a full order of magnitude lower than those obtained in machine bearings." The lubricant (synovial fluid) from arthritis patients' joints was no different in lubricating advantage from that of normal patients.

Other work suggested that a second fluid is also involved in lubrication, an interstitial fluid whose pressure increases as the load on the joint cartilage increases. Thus the coefficient of friction in a joint actually decreases as load increases.—*J.M.*

Right-Handed Ears

The two hemispheres of man's cerebral cortex each accept and process data from the opposite side of the body for many functions. This seems also to be true for hearing and speech, and during the last five years, otologists have had a technique, the dichotic hearing test, for studying asymmetries in hearing among subjects who have no neurological problems. Among the discoveries made with this test presented to the Acoustical Society of America this spring were several described by Sally Springer of the Stanford University School of Medicine.

The right ear, and thus the left hemisphere, seems to handle the sounds of speech better than the left, and the left ear and right hemisphere can better distinguish such differences in sounds as pitch. But, Dr. Springer told the Society, the way the test is usually given might show an asymmetry that does not exist. For the test, two different sounds are presented at the same time to the right and left ears, and the subject is asked to tell which sound he hears or to tell when he hears the one he has been asked to listen for. The response has been verbal—but the left hemisphere is believed to be the one chiefly responsible for speech. "This procedure," Dr. Springer said, "confounds processing and output." Her subjects responded manually, so that a message from the right half would not need to be processed by a speech center and only then reported.

She presented her subjects' ears with pairs of simple syllables—ba, ga, ta, da, pa, and ka—and asked them to press a button when either ear heard "ka." She found that the response time and the accuracy both were better when the right ear heard the syllable, and believes that the design of her experiment shows the distinction to be clearly perceptual rather than expressive.

Dr. Springer went on to investigate the asymmetry between the two hemispheres in the directing of speech. She compared the lengths of time that her subjects needed to respond to sounds manually or verbally coming in the left and the right ears: if the difference between the manual and verbal response was greater for the left ear than for the right, she said, that would indicate that the right hemisphere was doing some of its own processing of the signal, but was slower than the left hemisphere. If, however, the differences were equal, that would indicate the input to the left ear was handed over by the right hemisphere to the left for a verbal response (no time being lost in the transfer from right to left) and the left processed it for verbal response in the same time as it did signals from the right ear.

Verbal response was always faster than manual, Dr. Springer found, but the difference was the same for both ears. She surmised that the left hemisphere alone directs speech. This asymmetry does not become apparent until a child is about five years old, Dr. Springer told the *Review*. It occurs only when the ears hear competing sounds. No one yet supposes, she said, whether it is inherent or learned.—*J.K.*

Illusive, Fragile Fiscal Stability

Two years ago, after an intensive study of the financial plight of American colleges and universities, Earl F. Cheit, Professor of Business Administration at the University of California (Berkeley), hoisted a red danger flag: many institutions—including some of the nation's most prestigious—were in such serious financial difficulty as to jeopardize their future existence; many others were "headed for trouble." (*See "Hope and Despair" by Vincent A. Fulmer in* Technology Review *for March/April, 1972, pp. 66-68.*)

Now Dr. Cheit, whose work is sponsored by the Carnegie Commission on Higher Education, finds that in two years the situation has—at least temporarily—improved: colleges and universities have achieved "a fragile stability" in their financial affairs. (*For another view of college and university finances at least as pessimistic as Dr. Cheit's but far more radical in ap-*

proach, see below.)

That relative improvement is the result, Dr. Cheit says, of "the painful but undramatic process of adjusting operations and aspirations to relatively poorer financial circumstances. . . . Cost control has escalated to an extraordinary degree." Some of this control has been exerted by postponing expenses that in other days would have been considered routine—building maintenance, faculty salary increases. Some has been achieved simply by sharpened management techniques to eliminate waste. And some has been achieved by retrenchment, by reducing the emphasis on new programs and increasing the emphasis on cost-effectiveness in existing programs.

Dr. Cheit draws two conclusions:

☐ His studies indicate that most administrators believe "the quality of their institutions has not declined very much" under current financial constraints. He thinks the challenge which has resulted from efforts to economize and increase efficiency has surely been beneficial. But he is uneasy, too: "Systems for decision-making do not tell one what are the best objectives in educational terms."

☐ The present financial "stability" of many institutions is in fact very fragile. It has been achieved by delaying expenditures which cannot be delayed forever; it is based on "favorable assumptions" about external factors over which the institutions themselves have little or no control—such as private support, inflation, enrollment, and state and federal policy; and it has brought colleges and universities to a level of expenditure growth only 0.5 per cent above the rate of inflation, while the Carnegie Commission recommends that nothing less than 2.5 per cent growth over inflation will assure the maintenance of quality and innovation in higher education. "For a general condition of stability to continue for the longer run, the present expenditure-income relationships will have to improve," Dr. Cheit concludes.—*J.M.*

"Profit and Loss" in Universities?

Newspaper reports suggested that Professors Harold Bierman, Jr., and Thomas R. Hofstedt of Cornell were accusing the Ivy League universities of "crying wolf" by failing to report as income a large share of the annual increments to their wealth. But that was not exactly what the two Cornell economists meant.

In a paper on "University Accounting: Alternative Measures of Ivy League Deficits," Professors Bierman and Hofstedt agree with Earl F. Cheit (*see above*) that universities are "financially beleagured." To reveal the dimensions of the universities' problems and the effectiveness of their financial management, they propose a radical change in the way universities report their investments and their financial operations.

Professors Bierman and Hofstedt begin by noting a definition of "income" credited to economist R. M. Haig: "the money value of the net accretion to one's economic power between two points in time." Using that definition, they ask the Ivy League universities (to which they add the University of Rochester and M.I.T. as "honorary members") to include in their income accounts for 1970-71 their $842.6 million of capital gains on investments; these capital gains do not normally figure in university financial statements, where endowment is carried at "book" (cost), not "market," value. Two reasons for wanting to see capital gains treated more prominently: the resulting statement will better reveal the "financial condition of the university," and the data are "important in assessing the . . . performance of the university financial officers."

(M.I.T. officials think the Bierman-Hofstedt proposal is misleading: educational institutions are legally constrained to use funds given to them as endowment—including capital gains on those funds—in that way only, and it is not proper to suggest that endowment is in the same category as the institution's many more discretionary resources.)

Professors Bierman and Hofstedt also ask universities to show "deficits" as the final result of "profit and loss" statements, the amount of their expenses compared with the amount of their income—the latter to include tuition, gifts, and interest, dividends, and capital gains on their investments. The practice today, they say, is inconsistent. For example, some gifts are arbitrarily designated as endowment, others assigned to current expenses; depreciation of physical plant is never reported.

The result, they say, would be "deficits" far larger than those now recorded by any Ivy League universities according to their present methods of accounting, truer measures of "the net financial cost of the educational and research functions of the university" and a means to evaluate, year by year, each institution's "total financial performance, including its administration's abilities at raising money and investing the endowment portfolio."

Applying their proposal to the financial statements of the Ivy League universities in 1970-71 leads Professors Bierman and Hofstedt to express "a concern for the long-run future of the ten quality institutions." They find, for example, that with the single exception of Harvard, endowments are not large relative to current operations and to deficits as they recalculate them. The economists fear that present accounting leads to "excessive optimism that real, unresolved problems no longer exist," hiding "storm warnings of real dangers ahead."—*J.M.*

The Cost of Gifts

Beggars cannot be choosers, but colleges and universities—and their donors—might well be more perceptive about the real value of what they receive, or give. Some suggestions:

☐ Some three-fourths of private gifts to educational institutions are not entirely "free and clear monies"—that is, they are designated for some specific purpose to which the donor and the institution have (perhaps reluctantly, on the latter's part?) agreed.

☐ Pledges are not cash. "There is at any given time a substantial backlog of unpaid promises held by nonprofit organizations—perhaps as much as one year's gift income from some sources." Obviously, that's money that appears available to the institution—but isn't.

☐ Colleges and universities have special philanthropic problems in periods of high interest rates. These are periods when stock market prices are reduced, and most large private giving now takes the form of corporate shares; with prices down, donors receive less income-tax credit—and they tend to hold their shares for a higher market.

☐ Long-term pledges often yield far less than their face value, for the institution—to be realistic—must discount them to account for the interest *not* earned by the institution (but earned instead by the donor) on the funds which are pledged but not yet given. For example, a $1,000 pledge payable in five equal installments over five years and discounted at 8 per cent compound annual interest is only $799.

☐ Inflation, too, takes its toll on long-term pledges. When it finally arrives, money which when pledged was adequate for the purposes specified may not be quite enough, and either the original purposes must be compromised or the institution supplement the donor's funds.

☐ Long-term pledges of stocks put the institution at the mercy of the market—or the donor.

These observations are those of Vincent A. Fulmer, Vice President and Secretary of M.I.T., writing in the *Harvard Business Review (Vol. 51, March-April, 1973, pp. 103-110).* In a decade of Mr. Fulmer's tenure as the Institute's chief development officer, he has learned, he says, that there are "hidden costs of fund raising" so that "a dollar raised is not a dollar gained."—*J.M.*

How Four Dogs Meet In a Field, etc.

Puzzle Corner:
Allan J. Gottlieb

Next year Alice and I will be in New York; I'll be in the Mathematics Department of York College, a new campus in the City University of New York system, while Alice will be a graduate student at Rockefeller University.

Here's an indication of how long I've been out of "the city" (old-time provincial New Yawker talking). While crossing the street today I noticed that another pedestrian was nearly run over right in front of me. I gasped. A third pedestrian turned and said, "You must be from out of town. That wasn't even close—he missed him by two inches!" Two inches seemed close to me, but no one else was alarmed.

Help! A critical shortage of "speed" problems!

Even before proceeding to new problems, let me give Harry Nelson a chance for rebuttal on **M1**, originally published in May, 1972, on which we published Hallock G. Cambell's remarks in May, 1973 *(p. 60)*:

"I concur that the laws of chess require 'only a three-time repetition of the same position' but not that it is 'quite independent of the previous moves.'

"The first 17 moves by black and white which I sent in (plus the 18th white move) were needed to establish that the possibility of both black and white castling on either side has not been precluded. Thus with black's 27th move (KR—R2), the situation is changed; now black may no longer castle on the King's side. Similarly at moves 36W, 44B, and 53W. Thus even after move 61W, the same position has not occurred three times, 'with the possible moves of all the men unchanged'."

Problems

A bridge problem from Winslow H. Hartford:

J/A1 South has won a contract of six spades. West's opening lead is ♠3, taken by ♠A. East returns ♠4. How can South make the contract?

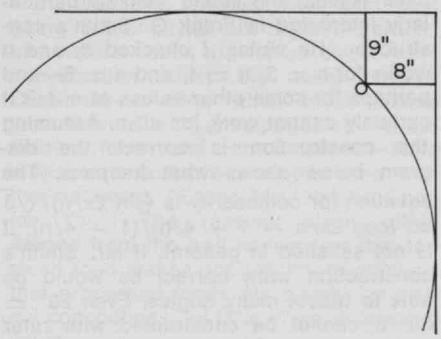
	♠ 6 5 ♥ A K 10 8 2 ♦ 10 4 ♣ K J 7 3	
♠ 3 ♥ Q 7 5 4 ♦ Q 9 7 3 ♣ Q 10 8 5		♠ A 4 ♥ J 9 6 ♦ J 8 5 ♣ A 9 6 4 2
	♠ K Q J 10 9 8 7 2 ♥ 3 ♦ A K 6 2 ♣ —	

David B. Smith has submitted a problem of a type I find quite enjoyable; he credits it to the late Professor Wroe Alderson of the Wharton School, University of Pennsylvania; Mr. Smith's solution was on Professor Alderson's desk at the time of the latter's death.

J/A2 Each of four dogs, located at the four corners of a square field, simultaneously spots the dog in the corner to his right and runs towards that dog, always pointing directly toward him. All the dogs run at exactly the same speed and thus finally meet in the center of the field. How far did each dog travel?

Our third offering is from Gordon J. McKinnon, Jr.:

J/A3 A circular table is pushed into the corner of a rectangular room. A coin resting on the edge of the table is 9" from one wall and 8" from the other. What is the diameter of the table?



Jerry Blum wonders:

J/A4 If you have just been given the dice at a crap table, what are the odds against your winning at least once?

Richard T. Bumby wants you to:

J/A5 Find the greatest common divisor of $a^m - 1$ and $a^n - 1$, where a is a positive integer.

Speed Department

A flagpole problem from H. W. Hardy:

SD1 Three flagpoles of 60 ft., 80 ft., and 100 ft. height are erected at the three corners of a triangular field, 100 ft. on each side. A ladder is placed at a point in the field so that it can be leaned to the exact top of each of the three poles. How long is the ladder, and where is it located?

A baseball puzzle from Norman Brenner:

SD2 The Yankees shut out the Orioles in Yankee Stadium by scoring n runs in the nth inning, for each n. What was the final score?

Solutions

The following are solutions to problems published in the March/April issue of the *Review*—except recall that **M/A1** was modified in June, so we start this month with **M/A2:**

M/A2 If (1) F is continuous from $(0, \infty) \to (0, \infty)$; and (2) for all $t > 0$, the sequence $F(t), F(2t), F(3t), \ldots \to 0$; then $F(x) \to 0$ as $x \to \infty$ [$x \in (0, \infty)$.

Jason I. Bitsky, a member of the Department of Mathematics at Princeton, writes, "I offered this problem to a group of hackers at tea. It was quite obvious to everybody that Baire's Category Theorem was called for. The only hitch was how to apply it. The key point (marked after the fashion of chess analyses with a double exclamation point) was brought up by Bob Israel. After that the solution was almost trivial." Here is the complete proof:

Let $\epsilon > 0$ and define for each positive integer n the set $k_n(\epsilon) = \{t > 0: f(nt) \leq \epsilon\}$. It is easy to see that each $k_n(\epsilon)$ is closed in $(0, \infty)$ as follows: The function f_n from $(0, \infty)$ into $(0, \infty)$ defined by f_n: $t \to f(nt)$ is continuous (because f is continuous), and so $k_n(\epsilon) = f_n((0, \epsilon])$ is the inverse image of a closed set under a continuous function. Now let $A_n(\epsilon) = \bigcap_{m \geq n} k_m(\epsilon) = \{t > 0: f(mt) \leq \epsilon$ for all $m \geq n\}$. Each $A_n(\epsilon)$ is closed (the intersection of closed sets). We claim that $\bigcap_{n=1}^{\infty} A_n(\epsilon) = (0, \infty)$. By hypothesis, $\lim_{n \to \infty} f(nt) = 0$ for each $t > 0$. This means that for each $t > 0$, there exists a positive integer n(t) such that $f(mt) \leq \epsilon$ whenever $m \geq n(t)$. This is precisely the assertion that $t \in A_{n(t)}(\epsilon)$. Since $(0, \infty)$ is a locally compact Hausdorff space, the Baire Category Theorem implies that some $A_n(\epsilon)$ must have non-empty interior; say $A_N(\epsilon)$ contains an open interval (α, β), $\beta > \alpha$. Choose a positive integer $M \geq N$ so that $*(M + 1)\alpha < M\beta$ (i.e., $M > \alpha/(\beta - \alpha)$). The inequality * implies that the intervals $(M\alpha, M\beta)$ and $((M + 1)\alpha, (M + 1)\beta)$ overlap. In fact, we have that for all $k \geq 0$ the intervals $((M + k)\alpha, (M + k)\beta)$ and $((M + k + 1)\alpha, (M + k + 1)\beta)$ overlap. Thus $\bigcup_{k>0} ((M + k)\alpha, (M - k)\beta) = (M\alpha, \infty)$. (!!) Now, if $t > M\alpha$, then t lies in some interval $((M + k)\alpha, (M + k)\beta)$, $k \geq 0$. Hence, $f(t) = f(M + k)t/(H + k) \leq \epsilon$, since $t/(M + k) \in (\alpha, \beta) \subset A_N(\epsilon)$ and $M + k \geq N$. Thus, $f(t) \leq \epsilon$ for all $t > M\alpha$, and this says that f(t) tends to 0 as $t \to \infty$. Remark: the proposition above is perfectly equivalent to the following statement which is interesting in its own right: If U is any unbounded open subset of $(0, \infty)$ there exists a $t > 0$ and a subsequence n_k of the positive integers such that $n_k t \in U$, for all $k \geq 1$. An elementary theorem in analysis asserts that every open set on the real line is a countable union of disjoint open intervals (α_n, β_n). Thus, the proposition above tells us that no matter how we select $\alpha_1 < \beta_1 < \alpha_2 < \beta_2 < \ldots \to \infty$, there is always a $t > 0$ such that infinitely many points of the sequence $\{nt\}_{n=1}^{\infty}$ lie in $U = \bigcup_{i=1}^{\infty} (\alpha_i, \beta_i)$, a non-obvious result.

Also solved by Hugh Barrie and the proposer, Mike Rolle.

M/A3 Every day for a week (of seven days) a class of 15 school girls went for a walk. They walked in five rows of three girls each. Each day, each girl had two new "row" mates. How did they do this?

R. Robinson Rowe submitted the following solution and comment: This is the classic problem T. P. Kirkman proposed on page 48 of the *Lady's and Gentleman's Diary* for 1850. It has thousands of solutions, but my favorite is that shown in the box at the top of the next page. The best analysis of the general problem, with the number of girls $= G = 3(2d + 1)$ arranged differently for d days is at pp. 193-223 of W. W. R. Ball's *Mathematical Recreations and Essays* (10th edition, 1937). Henry E. Dudeny in his *Amusements in Mathematics* says, "There are no fewer than 15,567,552,000

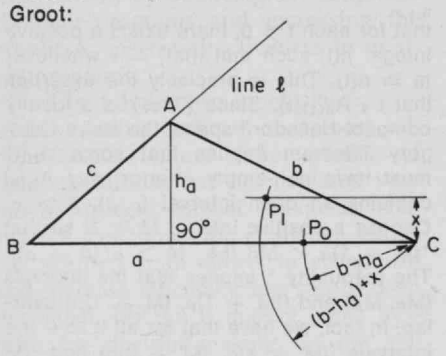
Day 1	2	3	4	5	6	7
ABC	ABG	AJM	AEK	AHN	AFO	AIL
DEF	BKN	BEH	CGM	CDJ	BGJ	BDM
GHI	COL	CFI	BOI	BFL	CKH	CEN
JKL	JEI	DKO	DHL	GEO	DNI	FGK
MNO	MHF	GNL	JNF	MKI	MEL	HJO

different solutions," citing the one above.

Also solved by Donald Uhl.

M/A4 Draw a triangle given lengths a and $(b - h_a)$, given angle B, and given that h_a is the perpendicular from A to BC.

The following construction is from Peter Groot:



1. Construct BC = a, angle B giving a line l.
2. Construct from C as a center the distance $(b - h_a)$ toward B on line a. This is point P_0.
3. Construct a line parallel to a at a distance of x above it, and the circle arc of radius $(b - h_a) + x$. The intersection is point P_1.
4. Construct more points P to form a curve; the intersection of this curve with line l will have $x = h_a$ and $AC = (b - h_a) + x = b$. Note that there are two solutions for $b > h_a$, one solution if $b = h_a$, and no solution if $b < h_a$.

Also solved by Mary Lindenberg, R. Robinson Rowe, and David B. Smith.

M/A5 Define $n\Delta = n(n + 1)/2$. When does $n\Delta + 1 = m^2$? Does the following algorithm work for finding the n and m? $n(i) = m(i - 2) * 8 + n(i - 4)$. Given: n and m are required to be integers.

A fine solution from John E. Prussing: Let $T(n) = n(n + 1)/2$ and $p = 2n + 1$. The condition that $T(n) + 1 = m^2$ can then be expressed as $p^2 - 8m^2 = -7$, which is a form of Pell's Equation. A fundamental solution is $p = m = 1$, from which one can ultimately derive the recursion formula $n(k) = 6n(k - 1) - n(k - 2) + 2$. Using $n(0) = -1$, $n(1) = 2$, one generates a sequence of solutions for n. Noting that for each $n - (n + 1)$ is also a solution for the same value of m, since $T[-(n + 1)] = T(n)$, one generates the remaining solutions. The values of m(k) corresponding to n(k) are given by $m(k) = 6m(k - 1) - m(k - 2)$, with $m(0) = 1$, $m(1) = 2$. The solutions are shown in the box at the right.

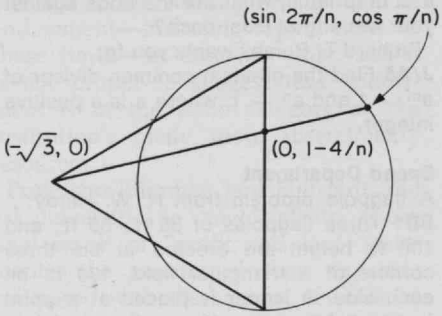
Also solved by John E. Prussing

Better Late Than Never

Concerning **DE1** John Schwartz, the proposer, writes

I take exception to Mr. Cutter's statement in his solution that it is very hard *not* to find a way to make six spades. The point is that the hand was one actually played at the bridge table, and it should be played with the defensive hands unseen. The problem is made trivial if all the hands are visible, in which case it is indeed easy to make the contract.

DE2 Harvey Ploss was going through back issues and found himself particularly interested in Frank G. Smith's construction. He writes: I checked it, and it works for n = 3, n = 4, and n = 6—and perhaps for some other values of n, but it certainly cannot work for all n. Assuming the construction is correct, the diagram below shows what happens. The equation for collinearity is $(\sin 2\pi/n)/\sqrt{3} = (\cos 2\pi/n - 1 + 4/n)/(1 - 4/n)$; it is not satisfied in general. If Mr. Smith's construction were correct he would be able to trisect many angles. Even $20° = 60°/3$ cannot be constructed with ruler and compass because it requires the solution of a cubic.



Richard Lipis, the proposer, feels that the solution given to **DE4** must be wrong, as he knows the numerical solution and the one obtained do not agree. Comments?

Solutions to the following problems have also come from the following readers

DE3 Mary J. Youngquist
DE4 Peter Groot
JN3 Thomas Kauffman
JA1 Roger Sinnott
JA2 Robert Baird and Michael Rolle
JA4 Baron P. de Haulleville, Robert Baird

n	T(n)	T(n) + 1	m:T(n) + 1 = m^2
.	.	.	.
.	.	.	.
.	.	.	.
−6	15	16	4
−3	3	4	2
−1	0	1	1
0	0	1	1
2	3	4	2
5	15	16	4
15	120	121	11
32	528	529	23
90	4095	4096	64
189	17955	17956	134
.	.	.	.
.	.	.	.
.	.	.	.

FEB4 Fred Lofgren
FEB5 John Radford

Solutions to Speed Department

SD1 The proposer believes the answer to be a flagpole 105.0206 ft. tall placed 32.0832 ft. from the 100-ft. pole, 68.0392 ft. from the 80-ft. pole, and 86.1936 ft. from the 60-ft. pole.

SD2 I solved this one! The answer: Yankees $\sum_{n=1}^{8} n$, Orioles nothing.

Allan J. Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics at York College of C.U.N.Y. Send problems, solutions, and comments to him at the Department of Mathematics, York College, 150-14 Jamaica Ave., Jamaica, N. Y., 11432.

Book Reviews

Continued from p. 9

A.E.C. has devised for the use of nuclear explosives in civilian application; and the project which is now the center of Commission interest: the breeder reactor. The book makes a substantial attempt to present evenly the opposing arguments on the radiation safety controversies of Ernest J. Sternglass and of John W. Gofman and Arthur R. Tamplin in their book, *Population Control Through Nuclear Pollution.*

H. Peter Metzger, a biochemist who is now a newspaper writer on technical issues, takes broader aim in a more angry book. His purpose is to show how the "Joint Committee and the A.E.C. changed from healthy adversaries into pals: how the Committee was transformed from a critic into an apologist, from an attacker of the A.E.C. into its defender, while the A.E.C. itself was reduced to a fanatically defensive protectionist clique of tenured bureaucrats who have been drawing job security from . . . the Manhattan Project . . . and whose best efforts since then have been divided between widely inappropriate technological adventures and the justification of these past mistakes." His story shows that the weaknesses of the A.E.C. and the supporters are grave indeed and how as a consequence the U.S. nuclear power program is in so much trouble. He invokes most of the known or suspected errors of the A.E.C. in supporting his views, drawn from the U.S. nuclear weapons acquisition and testing programs, the effects of radioactive fallout (the A.E.C.'s "body in the morgue" approach), uranium mine radon, a far wider spectrum of waste storage irregularities than Mr. Lewis documents, and a whole panoply of derelict "atomic gadgets." The latter includes the plutonium-heated "long johns" for deep sea divers produced by the A.E.C. for the Navy, one set of which contains a kilo-

gram of plutonium. The book is, in the words of its dust jacket, a "thoughtful and authoritative muckraker."

The two should be read together for a clear understanding of the nature and scope of the defects in the present administration of the nucleus. The source material from which the authors draw is so voluminous (the Metzger book cites 563 references) that their treatments even of similar areas complement and reaffirm one another, and taken together the books present a far more complete picture than either alone. Even so gaps remain: neither author discusses the ill-controlled transportation of highly radioactive wastes and weapons-grade fissionable material about the country (in which numerous weapons-sized amounts of material have been lost or misplaced), the dispersion of plutonium into Denver's air from improperly disposed plutonium-bearing wastes, or the very large and well hidden subsidy to the nuclear power program consequent on the failure to include in the value of the fuel the full costs of isotopic enrichment.

Both books mention only briefly the most recent and one of the gravest of the failures in the A.E.C.'s reactor program: the lack of assurance that the emergency systems designed to mitigate accidents leading to catastrophic release of radioactivity will in fact operate successfully if called on. A majority of the reactor experts in the A.E.C.'s own safety research centers believe that such assurance is missing. (See *Science,* 5 May 1972.) The important revelations of hearings on the systems with this reviewer and his colleagues as major participants unfortunately occurred after both books went to press.

The A.E.C. has become a secretive agency with an excessive emphasis on the vigorous promotion of nuclear power. The vigor has forced hasty and unwise selection among available technologies (e.g., the commitment to one particular breeder design program and inadequate support for fusion) and excluded full and complete assessment of alternatives. In too many cases the task of ensuring the public health and safety has had no more than the lowest priority. Not always able to support its positions by adequate evidence, the Commission has from time to time had recourse to unpleasant tactics as substitute.

It is now meeting sharply increasing public opposition to its plans. Although there has never been an insoluble technical obstacle to implementing conventional reactor technology in a safe, adequate, and reassuring manner, the program is in serious trouble. How serious this is cannot yet be known, for the general public presently is only dimly aware that things are wrong. These books and others to follow will begin to draw increased attention to the problems, and public exposure to the issues may bring remedial action. The A.E.C. has not been serving the country well in recent years and books such as these are a requisite to effecting the needed changes.

Henry W. Kendall, Professor of Physics at M.I.T., is a leader in the Union of Concerned Scientists.

If It Looks Like Cream but Isn't . . .

Book Review:
Emily L. Wick

Eater's Digest: The Consumers' Factbook of Food Additives
Michael F. Jacobson
New York: Doubleday, 1972, $5.95; paper: Anchor, $1.95

Food is a subject of more than usual attention these days. Not only is its price high, with old favorites like roast beef going out of style, but organic gardens and natural foods are topics of everyday conversation. Just the week before Christmas—a time when most people look forward with anticipation to the delicious food and drink ahead—*Time* magazine's cover was emblazoned with the statement, "Eating May Not be Good for You"! The reasons given within ranged from the well known fact that too much food makes one too fat, to opinions that processed foods are simply "chemical concoctions" of little or no redeeming value.

Whatever one's views of the quality of the food supply, they are very personal views. Each of us is his own food expert. We eat every day, not only because we need to but because we want to. We know exactly what foods we like best and how we like them cooked and served. These likes and dislikes derive from our earliest days, and food habits become part of one's personality and way of life. In the past such habits, reinforced by well-remembered parental admonitions, could be relied on to fall within reasonable nutritional guidelines because nutrients are almost always present in adequate amounts in foods produced and prepared at home by traditional methods. Unfortunately, things are not so simple now.

It is interesting and ironic that—despite our supermarkets stocked with thousands of items—selecting a diet of good nutritional quality is more difficult than ever before. The problem is *not* one of scarcity; there are simply so many products available that ordinary citizens lack sufficient knowledge to make wise nutritional and economic selections.

For example, which product should one buy—the orange drink so attractively advertised on TV, or real orange juice? The former may be more convenient to use, but are both comparable in food value? The label says the orange drink contains water, sugar, nonnutritive flavorings and vitamins; it is a pleasant drink and a good product. No one, however, should assume that it can be substituted for true orange juice which its appearance and taste so closely resemble. Real orange juice contains a range of nutrients and has significantly more food value.

A second example in which appearances are confusing: non-dairy creamer looks and tastes like cream but isn't cream. The label says it contains corn syrup solids, vegetable fat, sodium caseinate, dipotassium phosphate, emulsifier, sodium silico-aluminate, artificial flavor and artificial colors. How can one translate that information into some practical assessment of nutritional value?

Obviously nutritional guidelines learned "in the good old days" do not meet the challenges posed by modern processed and formulated foods. Obviously also, ingredient lists on labels do make food products seem to be "chemical concoctions." No wonder consumers are confused!

Consumer concern for the food supply has never been greater. It is reflected in many ways. Some people turn to organic gardening and natural foods in the belief that only "natural" products should be consumed. Instead of chemical fertilizers, animal wastes and decaying organisms such as leaves are used to restore the soil. "Chemicals" are avoided to minimize "poisons in our food." Other persons, equally sincere, believe the only way to feed the world's growing population is by fabricating from natural and synthetic components foods which resemble natural foods in appearance, flavor, taste and texture and which also can be adjusted in caloric content according to that population's need.

Michael Jacobson's *Eater's Digest: The Consumer's Factbook of Food Additives* deals with a major aspect of consumer concern, that of "additives." The Food and Drug Administration defines a food additive as "any substance, the intended use of which results or may reasonably be expected to result, directly or in-

directly, in its becoming a component of or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating or holding a food; and including any source of radiation intended for any such use . . ." No additive can be used in food unless and until the F.D.A. is convinced by thorough scientific evidence that the additive is safe at the intended level of use in the intended food application. In addition, no substance "found to induce cancer when ingested by man or animal" is permitted as an additive.

On the face of it, the definition is clear, the law straightforward and all to the public good.

Why then Dr. Jacobson's book and the widespread consumer concern?

Obviously, because the matter is very complex and anything but straightforward. Can the safety of any compound be proved or even predicted? How does one balance an additive's potential benefit as a preservative, a nutrient, or a flavor against its possible long-term risk to consumers? On the one hand, without additives "baked goods would go stale or mold overnight, salad oils and dressings would separate and turn rancid, table salt would turn hard and lumpy, canned fruits and vegetables would become discolored or mushy, vitamin potencies would deteriorate, beverages and frozen desserts would lack flavor and wrappings would stick to the contents." (B. Oser). But on the other hand, are we happy in the knowledge that per capita consumption of food additives in the U.S. was five pounds in 1970 and is expected to be six pounds in 1980?

Dr. Jacobson says that *Eater's Digest* "is intended to provide the average eater with an accurate, unbiased, and readable report on food additives." Not only does it accomplish this goal; most "average eaters" will find that shopping trips in the supermarket will never be the same again.

Dr. Wick, who is Professor of Food Chemistry in the Department of Nutrition and Food Science at M.I.T. leaves the Institute this summer to become Dean of the Faculty and Professor of Chemistry at Mt. Holyoke College. Dr. Wick studied chemistry at M.I.T. (Ph.D. 1951) and Dr. Jacobson biology (Ph.D. 1969).

Russian R&D: The Enigma Remains

Book Review:
Robert P. Mikulak

Science and Technology as an Instrument of Soviet Policy
Mose L. Harvey, Leon Goure, and Vladimir Prokofieff
Center for Advanced International Studies, University of Miami, Coral Gables, Fla., 1972, xiv—218 pp., $5.95 (paper, $4.95)

A Constant Among Some Variables

David McCord

Poem read before the Xi Chapter of Phi Beta Kappa, Massachusetts Institute of Technology, May 29, 1973

"Science is too serious a thing to be left entirely to the scientists."
—Sir Edward Appleton: *Science and the Citizen*

"It will be necessary that we look into the past, for there cannot be any prospect, or even perspective, without retrospect."
—René Dubos: *Pasteur and Modern Science*

"There is now said to be a general equation for the motion of any particle of matter anywhere in the universe."
—Scott Buchanan: *Poetry and Mathematics*

Well wired for sound at seven; at ten, a wireless operator.
I stuttered with Marconi and a man by name of Hertz.
My engineering uncle was the marvelous inflater
of a small boy's dreams. And when my mind reverts

to silicon, loose-couplers, or a variable condenser;
the key that closed my rotary, the letters of Ohm's Law:
the world is Hugo Gernsback! I can smell it, for my censer
swings the holy dust of ozone, instantaneous and raw.

Brass, copper, marble bases: Cantabrigian as this river;
but Clapp-Eastham, local lab name, hardly any now recall.
Unhidden back of panels, instruments that sent a shiver
down the spine. Perfection! Own but one, you gloried in them all.

And if well blessed with two or three far out in District 7,
in Oregon, as I was, Cambridge stood for that alone.
No QST in search of code from Kodiac to Heaven
but hales me back like some old dog to find his buried bone.

Romance to me was science; vice-versa. Newton's fluxions
hadn't reached me. There was Euclid, though. His solid Q.E.D.
could state a proven poetry by overtone deductions—
child-marriage of the complex to my simple ABC.

Things happening past Orion out my window, up the stellar
stairs, where his geometry put Euclid in the sky,
were no less real than circuits to my solder in the cellar.
We hadn't heard of pulsars; but the pulsing butterfly

at dalliance with his flowers in the field, the coded fracture
of sight rhythms and sound rhythms: cloud and wave and wind and leaf,
were variants of Morse; and, in my logic, manufacture
of the poetry, the lasting lyric utterance of grief

and joy. Sometimes the fluting, the 500-cycle level
of forgotten midnight sessions, still invades the poet's ear,

as in *The Screwtape Letters,* while plain words pursue the devil,
C. S. Lewis, the sound craftsman, tunes his doctrine in the clear.

The outer range of Milton to the inner range of Chaucer
called for vernier adjustment in the classroom later on.
Or poems half dry took off from paper like a flying saucer:
an exponential curve of inspiration come and gone.

Fine Hammacher (yes) Schlemmer tools, foot-power lathe with Skinner
chuck, had made me kin to Edison, the man in Menlo Park,
until the code uncopied died. Not toiler, now, nor spinner,
I saw the tube, transistor, and the voice put out the spark.

In college there was Millikan for his elusive measure
of the charge on the electron: mine was dandy—close to his!
But what that taught me indirectly was the need to treasure
the absolute in value when a word is all there is.

The undertones of C.P. Snow once bothered me. But thinking
back to my beginnings: a new science barely born,
a youngster on the fringe of physics, dazzled, his eyes blinking,
like the circumjovial planets bound, but like his fellows torn

apart by wide extended wings too "near to the secret places,"
as Wallace Stevens says, I see both cultures now as one.
Humanities and science in their myriad interfaces,
their myriad seeming conflicts, with the world's work unbegun,

are what we have, are *all* we have; but in such sole possession
we need some new alembic—who said fulcrum?—to insure
the counterplay of factors on the side of life. Obsession
with the wrong equations will but solve for yesterday the pure

disasters of Cassandras. Ecological disclaimers
cannot recognize the nature of the Nature that abhors
not vacuums, but all these jargoned lion-like mouse-tamers.
Oh, phosphopolypeptides! Wake the poet where he snores.

U.S. spending for research and development was propelled rapidly upward in the 1950s and 1960s by the successive crises of Soviet-American competition: the Korean War, the "bomber gap," the "space race," and the "missile gap." Indeed, during these years, research and development justified as helping to cope with "the external challenge" represented 75 to 90 per cent of the entire federal research and development budget.

No doubt the Soviet Union perceived a corresponding challenge and reacted similarly. As a result each side tried to outdo the other in devising new weapons and better defenses, and in winning international prestige, through science and technology.

By the end of the 1960s, however, the research and development efforts of the two super-powers were no longer quite so closely coupled. U.S. government support for research and development actually declined slightly at the end of the decade, while published figures indicated a continued rapid increase in Soviet research and development activities. The contrast led to official concern in the U.S. that an "R and D gap" might result in the U.S. falling behind in the development and application of technology, particularly for military purposes.

The authors of *Science and Technology as an Instrument of Soviet Policy* are among those who are alarmed about such an "R and D gap." The book is an attempt to document what they see as a serious threat to U.S. security—a perceived Soviet effort to achieve military superiority over the United States through technological pre-eminence.

The book is divided into two sections. The first is an analysis of "what the Soviets themselves have to say about their plans, their accomplishments, their shortcomings, their efforts to overcome shortcomings, and their expectations of immediate and long-term benefits from their enormous investment in science and technology." The second section contains excerpts from Soviet sources which discuss these topics.

The strong point of the book is the emphasis placed on the extraordinary efforts of the Soviet government to accelerate that nation's scientific and technological progress. The key role of science and technology in the development of the Soviet state has been stressed in official pronouncements since the beginning of the Soviet era, but this theme has received still greater attention in recent years. The translated Soviet documents in the second section of the book should prove a valuable resource for analysis of this phenomenon, which up to now has received surprisingly little attention in the West.

The book's most obvious weakness is in its assessment of the Soviets' objectives in placing so much emphasis on scientific and technological development. While the authors give considerable weight to ritual assertions about the struggle between capitalism and communism, such statements do not in fact provide an adequate explanation. The conclusion that in Soviet thinking "science and technology are . . . essential means for enabling the Soviet Union to

The Admiralty, Leningrad
Sketch by Joseph D. Murphy, M.I.T. '29

Is there a Soviet-U.S. R & D gap? If so, how can it be measured? The answers: elusive

achieve supremacy on a global scale and to gain its ultimate objective, i.e., the destruction of capitalism" seems to be grounded more in the authors' preconceptions than in the ambiguous documents cited as support. The difficulty in ascertaining Soviet intentions from official pronouncements is exacerbated by a lack of information on the level and direction of Soviet research and development efforts. Given the importance of science and technology as a component of national power, analysis of Soviet research and development activities—and comparison with the corresponding U.S. effort—remains an important task.

The U.S.S.R. publishes little statistical data on its own research and development activities; so comparison of the efforts of the two countries must rest on a myriad of assumptions, none of which can be adequately tested. And conclusions must be considered highly uncertain.

Official Soviet sources refer simply to a grand total of research and development funds, the outlay from the budget and the enterprises' own resources. We believe that additional funds for research and development are provided from other budget categories, both open and concealed.

The task of estimating the proportion of Soviet research and development outlays related to national security is even more difficult. No official Soviet information on the military research effort is published. Recent Western estimates range from 50 to 80 per cent of the published total.

Other difficulties which frustrate any attempt at direct comparison are differing definitions of research and development, uncertainty about ruble-to-dollar conversion, and many indications that the productivity of a Soviet research worker is, in general, much lower than that of his U.S. counterpart.

Despite these difficulties, it is still possible to make broad judgments about U.S. and Soviet research and development efforts.

Two comparisons seem to be generally accepted: the number of personnel engaged in research and development is considerably greater in the Soviet Union than in the U.S.; and since about 1967 the rate of growth of research and development expenditures has been considerably higher in the Soviet Union than in the U.S.

Over the last two decades the growth rate of outlays for research and development as published by the U.S.S.R. has varied considerably, there is substantial evidence that the rate of U.S.S.R. research and development growth is now slowing down significantly. From a peak of 18 per cent in 1960 the growth rate declined to a low of 8.7 per cent in 1966, then rose again to 17 per cent by 1970. Since then it has decreased steadily, with an annual growth rate of 7.2 per cent planned for 1973. The planned 1975 expenditure of about 18 billion rubles can be achieved if an annual growth rate of 7.5 per cent is maintained.

By comparison, U.S. funds for research and development have fluctuated more widely from year to year. Between 1961 and 1967 the average annual growth rate was 8.4 per cent. In the period 1967-1972, the growth rate dropped to 3.4 per cent. The low point was reached in 1970 when total expenditures did not increase significantly over 1969. Since then funding has begun to pick up again, with a growth rate of 7.5 per cent projected for 1973.

Primary attention is now being given to increasing the productivity of research and development in the U.S.S.R. One of the excerpts included in the book, which seems to have been neglected in the authors' analysis, clearly spells this out: "The development [of science] cannot continue at high rates mainly through the growth in the number of scientific workers and the expenditures on research. A transition is now taking place from *extensive* forms of scientific activity to *intensive*. And this presupposes raising sharply the effectiveness of scientific research . . ." (The quotation comes from an authoritative article written by two Soviet officials, D. Gvishiani, Deputy Chairman of the State Committee for Science and Technology, and S. Mikulinski, published in the party ideological journal *Kommunist* in November, 1971.) This approach is consistent with evidence that, due to an increasingly tight labor supply, further gains in industrial production must come largely from increases in productivity.

While the drive for increased industrial productivity is obvious, the motivation is not. Will the additional output go primarily to meet domestic needs or to increase the level of armaments? Although the book's foreword proclaims that "the documents gathered in this volume make these [Soviet] aims clear in the most authoritative terms," the promise is not fulfilled and the answer to the question remains elusive.

Robert Mikulak is Physical Science Officer in the Science and Technology Bureau, U.S. Arms Control and Disarmament Agency. He studied chemistry at M.I.T. (Ph.D. 1969) and in 1971 returned for a year of postdoctoral work in the M.I.T. Center for International Studies.

Must Scientists Be 'Organization' Men?

Book Review:
Joel Primack

Whistle Blowing
Edited by Ralph Nader, Peter Petkas, and Kate Blackwell, New York: Bantam Books, 1972, $1.95

"Scientists," Ralph Nader wrote in *Unsafe at Any Speed,* "have been in possession of information that is relevant to the elimination of millions of casualties, [but] they have shown only a slight appreciation that their special roles should require them to state forcefully in public forums the issues for discussion and resolution." In *Whistle Blowing,* which is based in part upon a "Conference on Professional Responsibility" held in January, 1971, Mr. Nader elaborates on this theme: The possibility of dissent within government and corporate bureaucracies "has become so restricted that common candor requires uncommon courage. . . . Corporate employees are among the first to know about industrial dumping of mercury or fluoride sludge into waterways, defectively designed automobiles, or undisclosed adverse effects of prescription drugs and pesticides. They are the first to grasp the technical capabilities to prevent existing product or pollution hazards. But they are very often the last to speak out."

A persistent focus upon the responsibilities of individuals runs through Mr. Nader's many critiques of governmental and corporate activities. *Whistle Blowing* presents the stories of a number of individuals—scientists, engineers, and technicians—who publicly criticized actions of their present or former employers, usually by revealing information that called into question the responsibility or

even the legality of these actions. Through their efforts wasteful government programs were terminated, dangerous chemicals were removed from food, and millions of defective automobiles were recalled. Such stories serve to substantiate and to personalize this book's more general arguments that an employee sometimes owes it to his conscience and to his fellow citizens to speak out against his employer, if he is sure of his facts and has exhausted all remedies within his organization; and that such "ethical whistle-blowers" deserve a fair hearing, the support of their professions, and the protection of the law.

Mr. Nader and his collaborators are acutely aware that to attack one's employer is ordinarily a rather drastic step which frequently leads to losing one's job and sometimes even to being blackballed by other potential employers. The book's aim is not to glorify the small number of martyred whistle-blowers, but rather to make the entire enterprise of whistle blowing less hazardous.

The extent to which a society is open and democratic, rather than closed and totalitarian, is measured by the amount of personal courage and sacrifice that is required for a man to follow his conscience. As large corporations increase their power over all our lives it becomes increasingly urgent to create countervailing forces. Labor unions came into existence to serve such a need, and the United Auto Workers indeed did help to protect one General Motors safety inspector whose diligence led to the largest automobile recall in history.

Professional employees often have much less protection than blue-collar workers. Their professional societies may have adopted high-sounding codes of ethics (some of which are reprinted in an appendix to this book), but they usually timorously avoid involvement in employment disputes. The least that they could do is establish independent review and arbitration procedures. Professional societies might also work to remove more subtle barriers to employee freedom—for example, pensions that "vest" late, are nontransferable, or are even cancellable after retirement if the employee engages in "any activity harmful to the interest of the company" (as is the case with du Pont).

Of course, a whistle-blower who fears for his job but wants to reveal what he considers important information can sometimes succeed in doing so anonymously. The burden of substantiating such data then falls especially heavily upon the reporters or others who receive it; but the press should always attempt to cross-check any information that is reported, to protect the public against misinformed or even malicious individuals.

Mr. Nader has set up a "Clearinghouse for Professional Responsibility," headed by co-author Peter Petkas, in order to help prospective whistle-blowers, including those who wish to remain anonymous. Nevertheless, they make no secret of their preference—on both moral and strategic grounds—for public accountability in whistle blowing. They approvingly quote Dr. Jacqueline Verrett, a Food and Drug Administration employee whose recounting in a television interview of her work showing that cyclamates cause deformities in chicken embryos was the beginning of the public controversy over cyclamates: "There should be no reason for reticence in discussing scientific information openly. I feel that scientists are obliged to present their information in a manner that is readily understandable to the public, but being cautious to keep it in proper perspective so that it is not unnecessarily alarming." Although Dr. Verrett was initially reprimanded by her superiors, she eventually received a promotion and is still engaged in chick embryo research at F.D.A.

Whistle-blowing is clearly a significant activity of our times, both because of the disproportionate effectiveness of some of the individuals involved and also because of the sometimes troublesome legal and moral issues that their activities have raised. This thoughtful little book offers advice and encouragement to incipient whistle-blowers—and also to those of us who will be listening to the results. (It is not at all a text.)

At the time of writing this review, the author was a member of the Department of Physics and a Junior Fellow of the Society of Fellows at Harvard University; he will join the faculty of the University of California at Santa Cruz this fall.

An Institute Informant

The Editors' digest of recent and current concerns at the Massachusetts Institute of Technology

Automated Steel Castings Research

M.I.T. and three industrial firms—Abex Corp., General Electric Research Laboratories, and Hitchiner Manufacturing Corp.—have joined in a research effort to automate the process of steel casting, and the Advanced Research Projects Agency of the Department of Defense will provide financial support—perhaps as much as $4.5 million—for a four-year program. The key to automation, thinks Merton C. Flemings, Jr., Professor of Metallurgy at M.I.T., is development of a reusable mold; as part of the A.R.P.A.-supported program, Professor Flemings and his colleagues will study work on casting steel at lower temperatures, where it is a semi-solid, and on using electromagnetic forces to contain and transport steel.

Better Ways to Fight Fires?

Forty U.S. engineering schools have already entered SCORE's newest contest for "innovative, practical hardware for the prevention, detection, and suppression of fires of every description." SCORE is Student Competitions on Relevant Engineering, Inc., and its first project was the Urban Vehicle Design Competition of August, 1972 (*see "68 Cars in Search of the Future," by Michael D. Feirtag in* Technology Review *for October/November, 1972).* The fire-fighting equipment designed by U.S. engineering school students will be tested in March, 1973.

Voluntary Giving Up, M.I.T. Down

Contributions to U.S. colleges and universities were at record high levels in the 1971-72 academic year—$2.02 billion, up 8.6 per cent over the previous year—according to the annual survey of the Council for Financial Aid to Education, Inc.

Private four-year colleges and universities received $1.267 billion, up 9.6 per cent.

Harvard University, which had reported the largest amount of total support for the previous five years of C.F.A.E. reports, yielded that exalted place to Emory University ($46.9 million, vs. Harvard's $46.5). M.I.T., among the top ten universities in voluntary support in 1970-71, slipped to 15th place, with $22 million in voluntary support.

C.P.B.'s "Reconcilation Candidate"

James R. Killian, Jr., Honorary Chairman of the M.I.T. Corporation, is widely regarded as "the father of public television" because of his successful role as Chairman of the Carnegie Commission on Educational Television whose 1967 report led to passage of the Public Broadcasting Act. Now, at a time of conflict between the Public Broadcasting Service and the Corporation for Public Broadcasting and of threatened political influence in the operations of public radio and television, Dr. Killian has been chosen Chairman of C.P.B.

After his election, Dr. Killian offered a four-point program:

☐ Settle differences on network priorities and procedures—in which White House interference has been hinted—between C.P.B. and P.B.S.

☐ Develop long-range financing for public television programming which "would remove it from the political hazards of annual appropriations." (Sensitive to this problem six years ago, the Carnegie Commission proposed financing by a tax collected on all new television sets when sold; that plan was never adopted by Congress in establishing C.P.B.)

☐ Further strengthening of local stations.

☐ A "reaffirmation" that public affairs programs are "an essential responsibility of public broadcasting."

Shortly after his selection, Dr. Killian told *The Tech,* M.I.T.'s student newspaper, that he accepted the C.P.B. Chairmanship "in order to help insure that public television moves ahead, demonstrating its independence from all political ties."

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Letters

Continued from p. 5

material 'growth,' . . . our tendency to seek technical solutions to every variety of human problem, . . . all of these . . . ought to be re-examined in the light of 20th-century experience." These concerns, to Rothermel, can be successfully bracketed by the assertion that "environmental management . . . has become an accepted social goal" (*p. 49*).

Even were Rothermel correct—and there are surely many who agree that, having set a "priority," we can now safely turn the environment back to the engineers—there remains the problem that questions of environmental protection have become deeply political in cities and towns all across the nation. The issue of limiting growth, for example, has appeared repeatedly on the agendas of prominent suburbs fearful of losing their charm. The continuing political debate over such matters is closely connected to the sales of environmental equipment, particularly to the public sector. A town uncertain of its future growth is correspondingly uncertain of the size and kind of sewage treatment it should choose. Simply to blend technology with improved marketing and managerial information is not going to help much here. And it could easily turn out to be helpful to equipment manufacturers but harmful to local governments and industries; "counter-intuitive" behavior in social systems does not always benefit the bureaucracy.

Those of us interested in the pollution control business not simply as an investment opportunity, therefore, would have been better served by a discussion of the ways in which profit can draw out innovative improvements, of how marketing can aggregate a market now fragmented into unprofitability. More ambitiously, one could have hoped for an exploration of opportunities for equipment manufacturers to cooperate with customers and customers' neighbors. Rothermel is clearly sensitive to the institutional problems here, and his observations would have usefully illuminated the administrative and political issues whose resolutions we shall have to live with, whether or not we participate in their formulation.

And who knows? He might have helped to edify those benighted executives who feel that "the main thrust of the environmental movement . . . has been . . . negative." (*p. 49*) Now really, is that any way to feel about a social goal?

K. N. Lee
Berkeley, Calif.

The writer is associated with the Institute of Governmental Studies of the University of California, Berkeley.

Look at the Entrepreneur, Too

Albert J. Kelley's article (*"Venture Management and Capital," March/April, pp. 34-38*) is very valuable as to what is expected of entrepreneurs by the venture capitalist; but that point of view should be tempered by the view of the entrepreneur himself.

The fact is that most entrepreneurs come from organizational service of several years in which the skills necessary to make a venture grow and prosper are acquired. I believe that the present industrial system is the primary spawning ground because of the natural conflicts which exist between the highly structured organization and the creative natural instincts of the entrepreneur. Anyone who has worked in a large organization knows that his job depends in many interactive ways on the structured goals of the organization as a whole. Communications, and the lack of communications, to a large degree influence the attitude of the individual regarding his effectiveness in the achievement of goals. The more creative the individual, the more will situations arise for the entrepreneur to interact—indeed, conflict—with the established system. Without going into the various kinds of frustration which can thus be generated through the internal politics, limitations of budgeting, personnel relationships, etc., I believe that frustration breeds a goodly number of new ventures.

A. S. Richardson
Burlington, Mass.

Equating Psychiatry . . .

Recently there has been much publicity about the Soviet practice of imprisoning political dissidents in mental hospitals.

Judge Charles Froehlich here in California seems to have been studying up on the idea, for he has sentenced Peter Bohmer, '65, to three months under psychiatric observation for taking part in an anti-war demonstration.

Clearly anyone opposed to U.S. foreign policy is crazy.

Donald Forman ('69)
LaJolla, Calif.

Wyman Fiske and the Sloan Fellows

The brief obituary of the late Wyman P. Fiske in the October/November issue (*p. 85*) missed the mark in one important respect: it failed to credit his great contribution in moving from the informal sponsored fellowship program to the full-fledged Sloan Fellowship Program, which began with a national competition for five candidates in 1938.

Since the grant from the Sloan Foundation during this initial period covered tuition in full and a substantial part of living costs (any employer contribution being optional), there were many individual applicants. Wyman Fiske traveled the country, interviewing them in their homes before a final selection was made. The sense of purpose he transmitted to those first selectees put the program on the right road for its subsequent great expansion.

E. Scott Pattison
(Sloan Fellow—1938-39)
Dunedin, Fla.

Institute Review

Chemical Engineering: A $7 Million Gift and a Major New Building

As spring brought bird songs to the Great Court, there came with them the rumble of bulldozers and piledrivers from the northeast: construction began April 25 on a $10 million, 130,000-ft.² building for the Department of Chemical Engineering.

And just as the job began, M.I.T. announced a $7 million anonymous gift—one of the largest ever made to the Institute by a single individual—of which $5 million was designated for the new building.

The donor was identified only as an alumnus.

That major gift brought to $11.7 million the total committed to M.I.T. for the new building, and the National Sponsoring Committee accordingly recommended that construction begin. A total fund of $13.1 million is being sought, with $1.8 million of that set aside for maintenance costs for the first 10-year period.

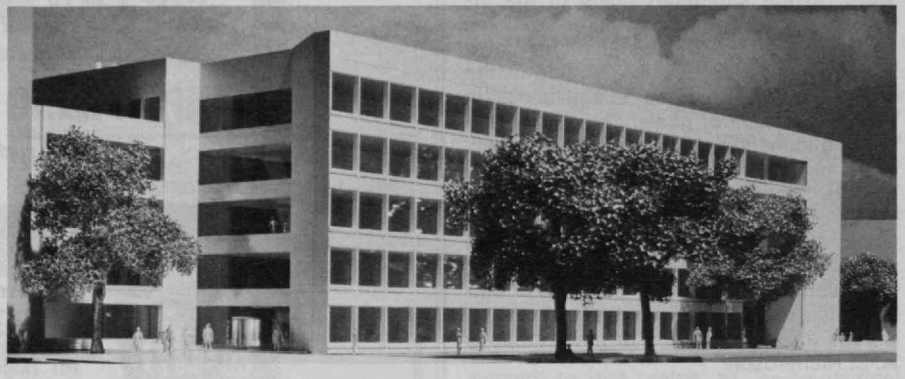
With $1.4 million to go, the National Sponsoring Committee—under the Chairmanship of J. Kenneth Jamieson, '31, Chairman and Chief Executive Officer of Exxon Corp.—pledged an intensive effort to finish the funding during the current year. "We are confident that the final cost will not exceed the goal of our campaign, and that the balance of the funding will shortly be secured," he said at the Sponsoring Committee meeting at which the construction go-ahead was given.

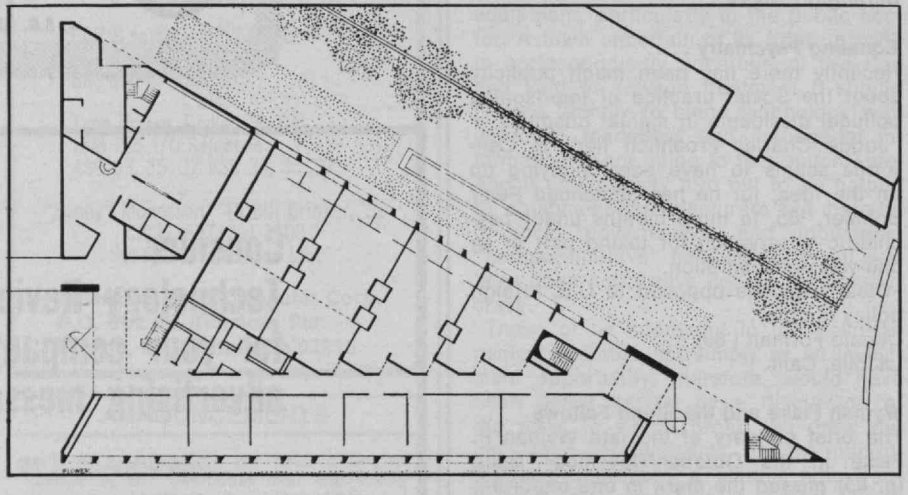
The new building—whose architect is Ieoh M. Pei, '40—will be built east of the Whitaker Building (life sciences), bringing the main educational buildings of the Institute to a front on Ames Street just north of the East Campus Houses. In five stories above the ground and two below, it will provide classrooms, laboratories, and offices to bring together in one structure parts of the Chemical Engineering Department which are now spread in six different campus locations and at Children's Hospital Research Laboratories in Roxbury.

Raymond F. Baddour, Sc.D.'51, Head of the Department of Chemical Engineering, is convinced the new building will substantially increase the Department's effectiveness. Already the popularity of the fields in which it is involved—fuel and energy, waste management, fertilizers, foods, pharmaceuticals, synthetic fibers, and new building materials, among others—has led to sharp increases in enrollment: the sophomore and junior classes are larger than in any recent year, and graduate enrollment is up some 22 per cent over 1970-71.

By 1978, thinks Dr. Baddour, student enrollment may reach 380—30 per cent more than today's—and the staff may have nearly doubled, from today's 25 to a total of 44.

M.I.T. founded chemical engineering as a discipline in 1888, and soon Warren K. Lewis, '05—who is now Honorary Chairman of the Sponsoring Committee for the new building—was soon designated to head a fledgling department. Its leadership has been secure ever since. M.I.T. consistently awards more graduate degrees in chemical engineering than any other college or university in the U.S. More than 10 per cent of the nation's teachers of chemical engineering obtained one or more of their degrees from the Department, and more than 10 per cent of its 5,300 living alumni are presi-





An unidentified alumnus has given $7 million and the sponsoring committee has voted to begin construction of a new building for the Department of Chemical Engineering, confident that the $1.4 million still needed can be raised promptly. Designed by I. M. Pei ('40) and Partners, the triangular structure will stand between the East Campus houses and the Carr Co. fastener plant, extending the academic buildings from the Whitaker Building to Ames Street. Large areas on the north will be laboratories, smaller rooms on the south classrooms, offices, and lounges.

dents, vice president, owners, or partners of industrial firms.

Financial Management: New Titles, but the First Team Remains on the Job

Reaching the age of retirement, Joseph J. Snyder, '44, who has been Vice President and Treasurer of the Institute since 1951, will relinquish the title of Vice President but will continue in a full-time capacity as Treasurer of the Corporation.

Two other changes will be made concurrently on July 1, according to President Jerome B. Wiesner:

☐ Paul V. Cusick, who has been Vice President for Business and Fiscal Relations since 1970, will become Vice President for Fiscal Relations, reporting to Paul E. Gray, '54, Chancellor.

☐ Stuart H. Cowen, Comptroller, will become Vice President for Financial Operations, also reporting to Dr. Gray.

The changes, said President Wiesner, mean that—despite Mr. Snyder's reaching retirement age—the Institute's financial management team, who together have served M.I.T. for a combined total of more than 70 years, "will continue to be the mainstay of the Institute's financial management." The changes in titles represent adjustments to correspond with relationships and responsibilities as they have developed in recent years. But, President Wiesner said, he hopes the new organization will also "bring the financial management closer to the academic operations of the Institute."

In a statement to *Technology Review*, James R. Killian, Jr., '26, Honorary Chairman of the Corporation, said that "this team has been extraordinarily able and successful in the management of the Institute's financial affairs and contractual relationships, and M.I.T. has had an influence far beyond its own boundaries in devising and applying sound policies for business and contract management and negotiation."

As Vice President for Fiscal Relations, Mr. Cusick will be responsible for fiscal relations with the federal government, with research sponsors, with the Charles S. Draper Laboratory, Inc., and with other universities; he will serve as contracting officer for building contracts and will be responsible for patent and copyright licensing.

Mr. Cowen will be the "inside man," responsible for internal financial management—including budgets, money and banking functions, accounting and payrolls, benefits, and financial programs.

Mr. Cowen's assignment will also include serving as the Institute's contracting officer for sponsored programs, and the Division of Sponsored Research—renamed to be the Office of Sponsored Research, will report to him.

Mr. Cusick was graduated from Bentley College of Accounting in 1939 and came to M.I.T. in 1944. After ten years in various sponsored research management assignments, Mr. Cusick became Assistant Treasurer of the Institute in 1954 and was made Comptroller in 1957.

Mr. Cowen graduated from Harvard College and the Harvard Business School (M.B.A. 1948) and worked in industry before joining the Division of Sponsored Research in 1960. He was Director of M.I.T.'s Fiscal Planning from 1964 to 1968.

J. J. Snyder

P. V. Cusick

S. H. Cowen

A Truck Route Past M.I.T.? No Way: "Disastrous to the Area"

Whenever a heavy truck comes by the Draper Laboratory on Albany Street, the machine shop stops work, some laboratory experiments are turned off, and at least one worker turns on the amplifier in his telephone headset.

A Center for Space Research worker says, "We don't do any sensitive experiments during the day because of noise problems."

The National Magnet Laboratory defers its sensitive experiments until after midnight to reduce the effects of vibration and electromagnetic interference—trucks, again.

The Research Laboratory of Electronics has had to shield most of its present quarters (and its future ones, in the new Fairchild Building) to prevent electromagnetic interference from ignition systems—mostly of trucks.

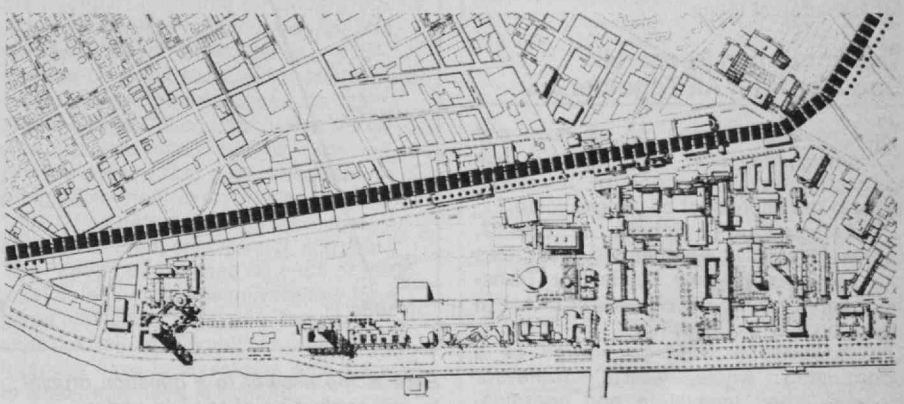
No wonder, then, that while the Boston Transportation Planning Review last winter worked out a plan for a truck highway to run along the route of the railroad connector through M.I.T.'s north campus, the Institute launched its own study of Cambridge transportation and the problems trucks cause in the Institute's area. (The B.T.P.R. study was a response to complaints of the growing truck nuisance in Cambridge residential streets, mostly in the Central Square area.

The first discovery of the M.I.T. Planning Office, which conducted the study, confirmed what few people needed to be told: lots of trucks do pass M.I.T. every day. On a typical day in March, 1972, the Planning Office counted nearly 1,300 trucks passing the Institute's main entrance at 77 Massachusetts Avenue—680 eastbound, 597 westbound. Even more used Main Street past the Ford Building—nearly 2,000. But a 1963 study showed that 90 per cent of all this traffic was local trucks—those with either an origin or a destination in Cambridge. A highway designed to bring trucks through Cambridge from east to west would serve but few of them.

Measurements of noise outside M.I.T. buildings showed levels of 90 db. or more when trucks were passing in front of Building 20, Westgate, Eastgate, and the Bitter National Magnet Laboratory; such levels "far exceed acceptable standards," says the Planning Office report.

Inside the same buildings, trucks passing nearby caused noise levels of 50 to 60 db., when 35 to 40 db. are generally recommended maxima for homes.

Nighttime readings were also high—be-



Responding to Cambridge residents' protests of noisy, smelly truck traffic on residential streets, the Boston Transportation Planning Review late last year suggested a truck highway along the railroad tracks in M.I.T.'s north campus.

No way, replied the M.I.T. Planning Office after some intensive studies. The highway would affect many campus activities, and in any case it would not solve the problem which led to its proposal.

tween 70 and 80 db. outside of Eastgate and Westgate student residences and between 40 and 50 db. inside. Little wonder, thinks the Planning Office, that some students find parts of their apartments in these buildings "uninhabitable."

The Planning Office report concludes with a strong recommendation against the road—and *for* a thorough study of how goods move into, through, and out of Cambridge.

Multiplying $1 Million by Three: A Unique Gift for the Loan Fund

A $1 million gift, to be paid to M.I.T. at the rate of $100,000 a year for the next ten years, will permit the Institute to increase its student loan program by some $3 million during the next two academic years.

The $1 million gift was announced this spring. It is anonymous, credited only to "the imaginative generosity of an alumnus."

Here is how the Institute will gain so much leverage for so little—relatively—money: M.I.T. will borrow capital for student loans from commercial banks. The $100,000 a year will be used to pay the difference between the interest paid by students to the Technology Loan Fund and the bank interest on the money loaned to M.I.T.

Because the gift "makes it possible to bring in bank capital on a long-term loan," said Joseph J. Snyder, '44, Vice President and Treasurer of the Institute, it "tends to stabilize the entire loan Program" at M.I.T. Thus, he said, the gift will have "a very marked impact" on the Institute's financial aid program, which M.I.T. regards "among its highest fund-raising priorities."

The Technology Loan Fund, the first major loan fund set up by any college, was established in 1931; it is now the nation's largest, students at M.I.T. having benefitted from more than $12 million in loans from this Fund during its history.

The Technology Loan Fund has recently been supplemented by loans through the federal government's National Direct Student Loans and the Guaranteed Loan Program, because capital resources of the Loan Fund alone have been insufficient to meet students' increasing needs for low-interest loans.

Transportation Research: Can We Get It All Together?

"You have a rail man, an air man, and a highway man who don't typically talk to each other, and none of the three talks to the economist or the politician."

That's how Paul O. Roberts, Jr., S.M.'57, Professor of Civil Engineering, describes the need for the new Center for Transportation Studies, which he will direct in the School of Engineering.

"Transportation must be viewed as a coordinated whole," says Professor Roberts, "and innovation and coordination are the keys to getting people and things moving more quickly and efficiently."

In the formal announcement of the new Center this spring, Dean Alfred A. H.

(Continued on page 87)

Toward an Analysis of Student Aid Policies and their Effects: Student Quality and Diversity

What is the relationship between M.I.T.'s financial aid policies and the quality and diversity of its undergraduate student body?

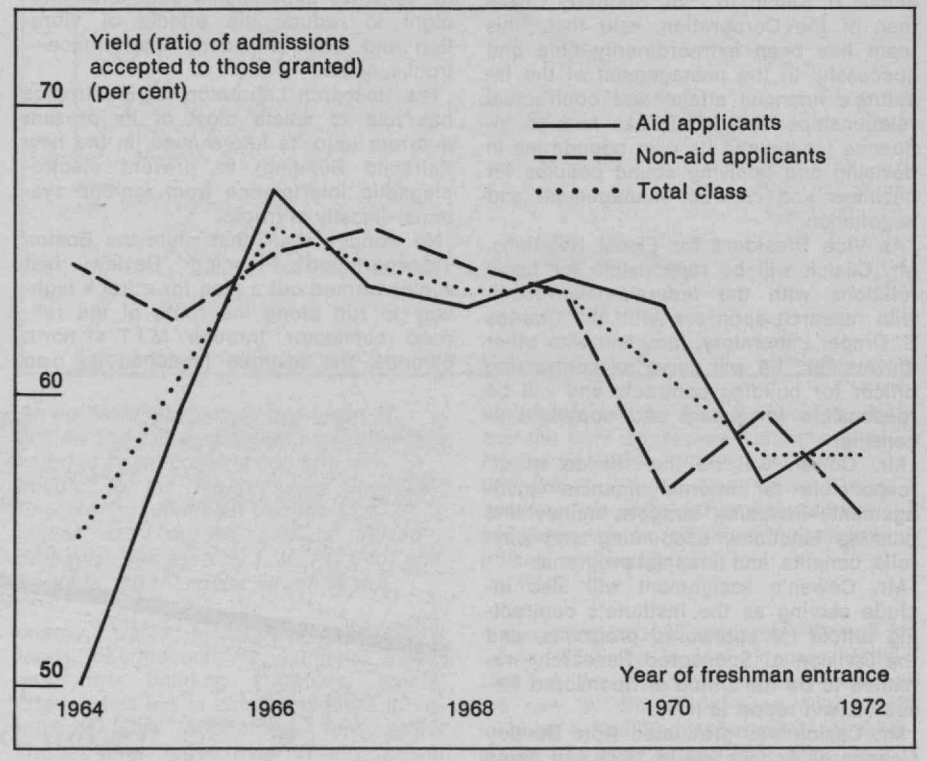
Reporting to the faculty this spring on a year-long study of that question, the Faculty Committee on Undergraduate Admissions and Financial Aid (Leon Trilling, Professor of Aeronautics and Astronautics, Chairman) concluded that diversity—but not quality—had been affected by the necessities which require the M.I.T. financial aid program to rely "more heavily on loans than those of its principal competitors."

There is no grand scheme by which can be expressed the relationship of financial aid to admissions and to the characteristics of the student body. M.I.T.'s policy is, in fact, to separate admissions from financial considerations—to assure that finances are not an obstacle to any admitted student who determines to attend M.I.T.

First, some basic facts:

1. The cost of attending M.I.T. has increased steadily—almost exactly in parallel with the rising median U.S. family income, a rate of advance considerably greater than that of the U.S. cost of living. Each year there is published in the General Catalog an estimate of the average student's basic costs for an academic year. In 1965 that estimate (including tuition, the amount of which we show in parentheses) was $3,054 ($1,700); by 1970-71 it was $4,050 ($2,500). This year the total cost estimate is $4,851 ($2,900), and the current estimate for 1973-74 is $5,150 ($3,000).
2. Throughout this period, M.I.T. has asked the parents of all students applying for financial aid to report their financial resources and obligations. The uniform format of the College Scholarship Service is used, so that M.I.T.'s data are presumably consistent with that of any other college where that family's student is applying for financial aid.
3. On the basis of parents' data as analyzed by C.S.S., M.I.T. makes a determination of each student's financial need. This is the difference between the estimated basic costs for a year at M.I.T. and the amount which, on the basis of C.S.S. data, M.I.T. believes the family and the student himself may reasonably provide toward his education. This difference between expenses and resources is known in the terminology of the financial aid field as "need."

Other schools to which the same student applies may, of course, assign him



Here is the answer to a question crucial to any evaluation of M.I.T.'s undergraduate financial aid policies: considering all those who have been granted admission to any freshman class, how many of those who must have scholarship and loan resources elect to come, compared with those who do not need financial assistance? These data give evidence that since 1964-65 M.I.T.'s financial aid package has been good enough to make it a non-issue in most applicants' decisions.

different amounts of scholarship, loan, and work assistance and may expect different amounts of family contributions toward education. But differences in the determinations of "need" between M.I.T. and its principal competition are discussed before offers are made, says Jack H. Frailey, '44, Director of Student Financial Aid. These differences are "usually slight," and they are "seldom large" after the discussions, he says.

4. Since 1965, the amounts and form of financial aid available at M.I.T. and the policies under which it is awarded have been in flux. Here is a summary:

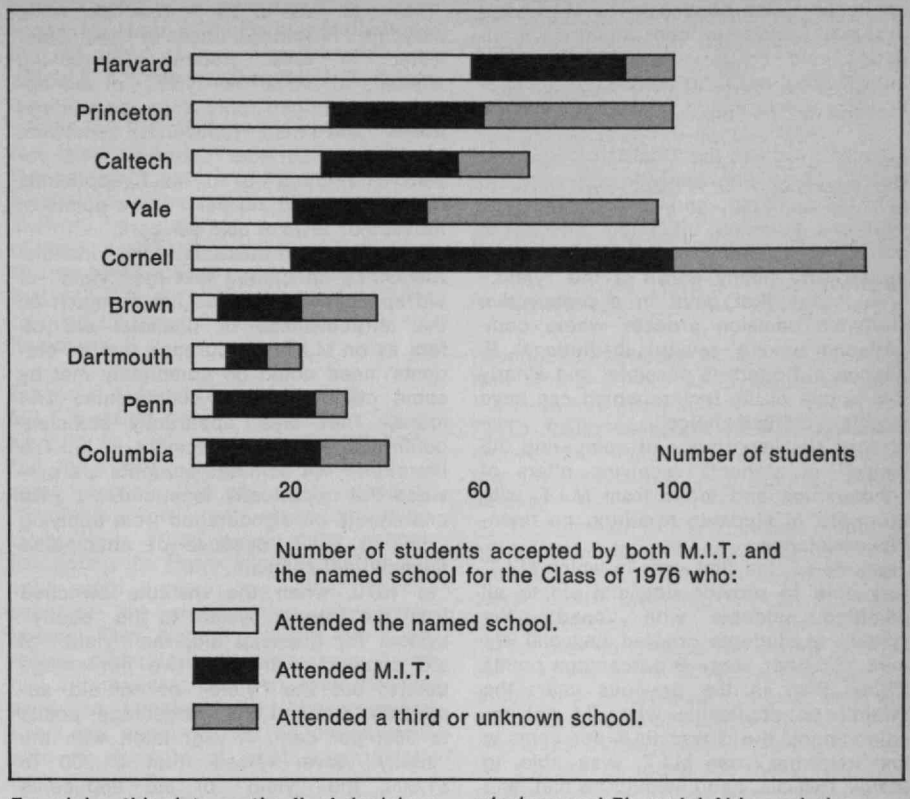
☐ 1964 was the last year under which the Institute admitted any students under an "admit-and-deny" arrangement: some applicants were admitted as being qualified to attend M.I.T. but told that, no matter what their need, no financial aid was available.

☐ One year later, by the start of 1965, the Institute for the first time said it would meet the aggregate need of all entering freshmen through scholarships and loans. The financial aid offers continued to vary in accordance with the qualifications of the applicant: those deemed most attractive for M.I.T. received more help in the form of scholarships, those less qualified were asked to accept more financial aid as loans.

From 1965 to 1969, as costs and typical "need" rose, an ever-smaller proportion of the total financial aid could be provided in scholarships and more had to be given in loans—this despite the fact that $1.17 million of unrestricted funds were used to augment the scholarship program. In this sense, the aid packages grew slightly less desirable each year: the average indebtedness of students matriculating in those years was calculated to rise from $2,900 in 1966 to $3,600 in 1970.

☐ Beginning in 1970-71, in order to set a ceiling on the burden of debt that an undergraduate could incur, M.I.T. switched from the "merit" system to an "equity" system. Now all students with financial "need" were asked to use loans and term-time work in combination to cover the first $1,200. Those with "need" above $1,200—no matter how their qualifications for study at the Institute compared with those of other admitted applicants—were given scholarship grants. Thus "need" above the fixed threshold was met by scholarship; no student accumulated more than $1,200 of indebtedness in a year; and no student was rewarded for scholastic excellence with extra scholarship funds. The basic strategy which limits the debt any student must incur to attend the Institute makes M.I.T.'s financial aid program unique in the U.S., though some Ivy League schools have been using an adaption of the system which involves several ceilings of loan and self-help, the ceiling applied in any particular case being a function of need or academic excellence or both.

In 1970-71, the "equity" level was raised to $1,600, and students were asked to supplement loans with term-time jobs up to this amount. This "equity" level was unchanged for 1972-73; it will be $1,750 for 1973-74.



Examining this data on the final decisions of applicants for admission and financial aid in the M.I.T. Class of 1976, the Faculty Committee on Undergraduate Admissions and Financial Aid concludes that the Institute "draws at least as well as our competitors in spite of a weaker aid package."

Financial Aid and the Applicant Pool

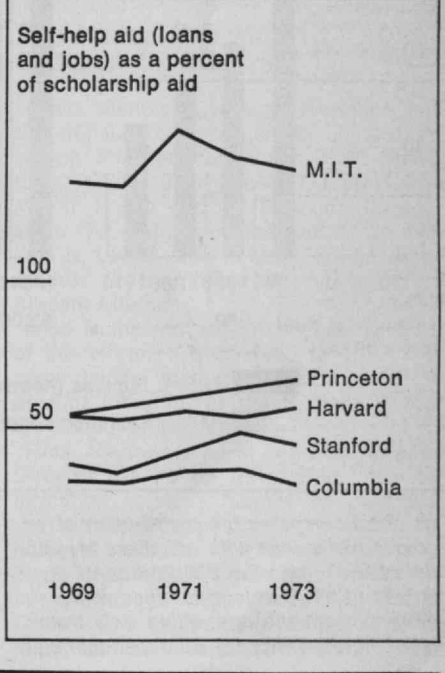
What, then, can be said of how all this affects the make-up of M.I.T.'s undergraduate classes?

The first statistical point is the number of secondary school students who apply to attend M.I.T. Here is that data: The applicant pool rose fairly steadily, from 3,689 to 4,417, between 1966 and 1969 (the years in which M.I.T. met all its students' need under the "merit" system). In 1970-71, when the financial aid program changed to meet "need" under an "equity" system, the applicant pool for the Class of 1975 increased slightly to 4,474.

In 1971 came a big drop to 3,609 applicants for the Class of 1976—a trend which M.I.T. shared with many other private colleges. The number of applicants has been essentially unchanged since then. During this three-year period the financial aid plan has remained unaltered except for a $400 increase in the "equity" level in 1971-72.

In sum, though the total number of final

Many institutions with which M.I.T. competes for students "meet a significantly higher fraction of their students' 'needs' with scholarships" than does M.I.T., says the Faculty Committee on Undergraduate Admissions and Financial Aid. For this purpose, "need" is defined as the difference between the cost of attending an institution and the resources, as estimated by the College Scholarship Service, which a family may be expected to provide toward that cost. The Institute is pledged to meet every aid applicant's full "need," as defined above, by a combination of loan, scholarship, and job. The "need" determined by each of the most selective private universities for a given applicant "is roughly the same," says the Faculty Committee, and differences have to do largely with the ways in which that need is fulfilled.



applications for admission to M.I.T. has dropped by 23 per cent since 1970, financial aid policies seem to correlate little if at all with the number of applications for admission.

Financial Aid and the "Yield"

Not all those who apply to attend M.I.T. can be admitted, and not all of those who are admitted ultimately choose to come; the percentage of students admitted who finally enroll is the "yield." This is the first point in a prospective student's decision process where comparisons among several institutions' financial aid offers is possible, and clearly this is one of the factors which can have an effect on final choice.

Hence the importance of comparing the "yield" of students receiving offers of scholarships and loans from M.I.T. with the yield of students requiring no financial assistance.

In 1965-66, the first year in which M.I.T. was able to provide financial aid to all admitted students with "need," the "yield" of students granted financial aid rose to 59 per cent—9 percentage points higher than in the previous year; the "yield" on applicants who did not require financial aid was 64.8 per cent. In the following year M.I.T. was able to assure that all "need" would be met, and the "yield" on aid and nonaid applicants was the same—66 per cent; it was the first time the "yield" of aid applicants was as high as the usual "yield" of non-aid applicants.

Between 1966-67 and 1969-70, while students requiring financial aid were asked to take gradually increasing amounts of loans, the "yield" of aid applicants dropped only four percentage points and then recovered somewhat to end the four-year period at 64.6 per cent. The "yield" of all M.I.T. applicants fluctuated within 2.3 percentage points of its 1966-67 level of 65.8 per cent.

On the basis of these data, the Financial Aid Office concluded that the "yield" of aid applicants depended not so much on the attractiveness of financial aid offers as on M.I.T.'s assurance that its students' need could be completely met by some combination of scholarships and loans. That was apparently sufficient confirmation of the statement in M.I.T.'s literature: "All admitted students are provided the opportunity to attend. . . . No one should be discouraged from applying . . . to M.I.T. because of anticipated financial difficulties."

In 1970, when the Institute switched from the "merit" system to the "equity" system for financial aid, the "yield" of aid applicants dropped two percentage points; but the "yield" of non-aid applicants dropped 7.6 percentage points to 56.6 per cent. A year later, with the "equity" level raised from $1,200 to $1,600, the "yield" of aid applicants dropped to 56.4 per cent while the "yield" of applicants not receiving aid offers rose to 59.6 per cent.

This year, one in which the equity level was held at $1,600, the aid-applicant "yield" increased to 59.2 per cent while the non-aid applicant "yield" dropped to 55 per cent.

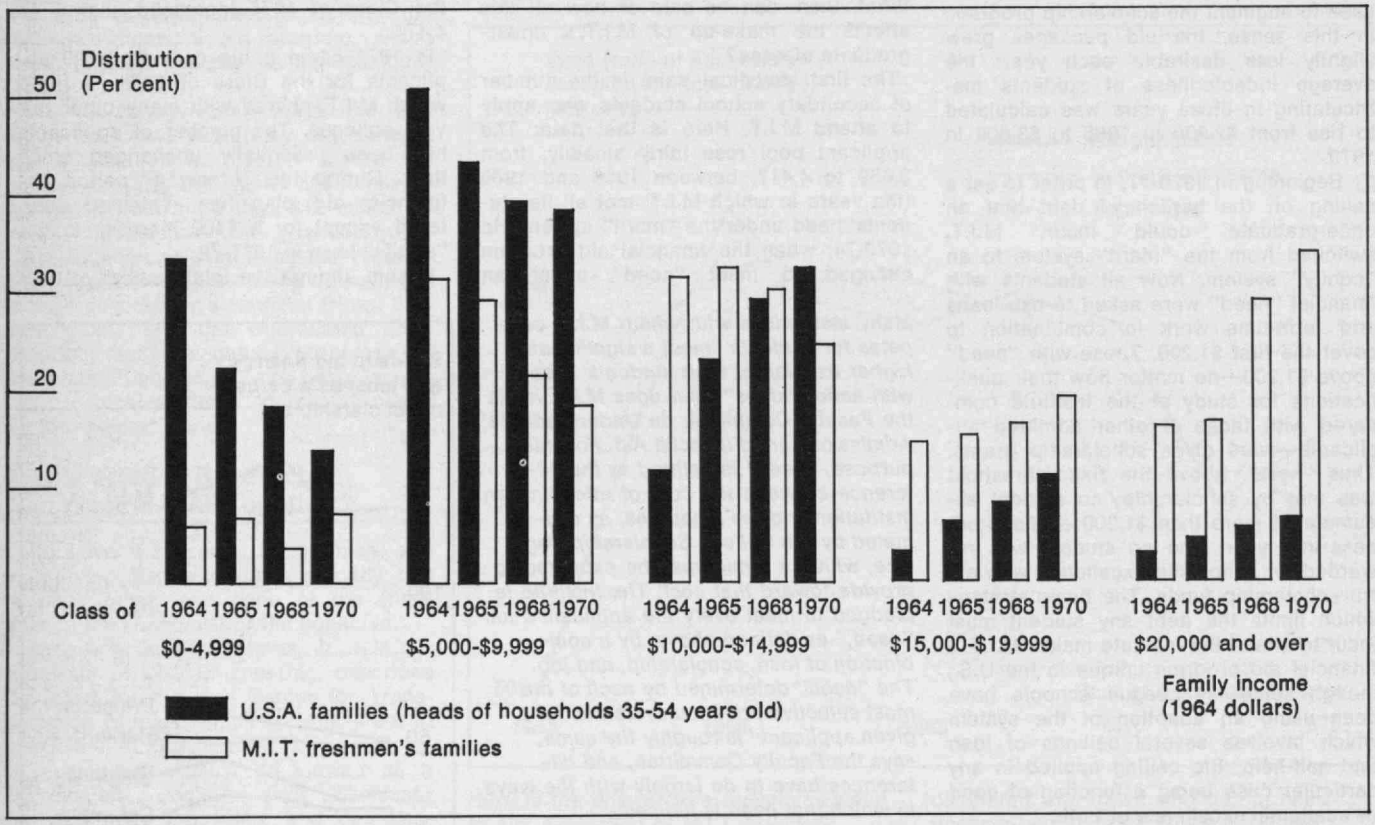
These data are uncomfortably erratic, but the graphic plot (*p. 84*) suggests one conclusion: If there is a crisis point in the quality of the M.I.T. aid package below which prospective students find it simply unacceptable and the "yield" plummets, that point has not been reached since 1964-65.

Financial Aid: M.I.T. and the Competition

Another possible question: How do M.I.T.'s financial aid offers compare with those of other schools?

In this context, the "competition" with which M.I.T. can be compared consists of a few schools whose costs and financial aid policies are generally similar to the Institute's. In general, these schools determine "need" in much the way M.I.T. does, and the difference an applicant sees between M.I.T. and a "competing" school is likely to be not in total "need" but in the amount of scholarship—instead of loan and self-help—provided to meet that "need." Throughout the period under discussion, M.I.T. has consistently offered less scholarship and more self-help and loan, on the average, than its "competition."

M.I.T.'s funds for scholarships have been growing at 2 per cent a year while its undergraduates' total "need" has been growing at 8 per cent a year over the last five years, says the Faculty Committee. The new anonymous gift to un-



This chart compares the distribution of incomes of families with members attending M.I.T. with the distribution of incomes of all American families with children of college age, using data from the Institute's Office of Student Financial Aid. It shows that M.I.T.'s proportion of students from low-income families has been essentially constant while those families have been (from 1964 to 1970) a decreasing proportion of the population; that M.I.T.'s proportion of students from middle-class families has remained constant in comparison with an increasing base; and that both M.I.T.'s and the nation's proportion of high-income (over $20,000) families has doubled between 1964 and 1970.

derwrite the interest on loans (*see p. 84*) will probably lead to further emphasis on loans in the student aid program; a major Institute effort to increase all student aid funds by $10 million by 1980 has encountered what the Faculty Committee admits is "considerable resistance," though "some appreciable funds" had been raised before the $1 million for loan interest was announced.

Yet financial considerations are not the overwhelming reason why students accepted at M.I.T. decide to go elsewhere. In 1969-70, of the 652 students offered admission to M.I.T. who instead enrolled elsewhere, 90 went to Harvard or Radcliffe, 58 to California Institute of Technology, 55 to Princeton, 53 to a number of state universities. Replies to questionnaires sent to the students who decided to go elsewhere indicated that a decision to pursue a liberal arts education at an equally expensive school was at least as common as a decision not to attend M.I.T. for financial reasons.

The Financial Aid Office believes that M.I.T.'s success in drawing freshman financial aid applicants from the principal competitors—Harvard, Caltech, Yale, Princeton, and Stanford—is essentially the same now as it was in the early 1960s, when M.I.T.'s "merit"-oriented strategy allowed competitive awards. The only exception may be Harvard (*see chart, p. 85),* thinks the Faculty Committee.

Public universities, whose subsidized tuitions are much lower than M.I.T.'s, may be emerging as competition. The Institute's actual loss of applicants to these institutions has not grown significantly. But a student whose parents are asked by M.I.T. to contribute more toward M.I.T.'s costs than the full cost of a state university must sense a substantial "cost penalty" for choosing M.I.T.; how large a penalty will be tolerated?

Financial Aid and Student Quality

If M.I.T. no longer gives special scholarship rewards to outstanding students with financial need—all are treated alike under the "equity" system—while many other colleges continue to do so, what of the quality of M.I.T.'s students?

That is the hardest question of all, because quantifying intellectual quality is difficult at best—and particularly difficult at M.I.T. under pass/fail freshman grading. College Entrance Examinations scores of M.I.T. freshman have been essentially unchanged in the past four years. Many on the M.I.T. faculty declare that their freshmen today are superior to those of one or two years ago; no one proposes the opposite.

Two reasons may be advanced for this apparent constancy of quality.

☐ The group of applicants available for M.I.T. to consider admitting, while it may be reduced (the number of applicants was almost identical in 1971-72 and 1972-73), is still large enough that a fully-qualified class can be identified, says Peter H. Richardson, '48, Director of Admissions.

☐ The same fiscal constraints that have shaped the Institute's aid policy in the past four years are operating at other schools too, including increasing dependence on loans in place of scholarships; the net effect of their "need/merit" programs is not nearly as dramatic as it may appear.

While the first of these bulwarks is tenuous (there obviously must be a point in the applicant pool beyond which quality begins to deteriorate), the second is likely to be reinforced with the passage of time. Mr. Frailey believes that more and more aid officers are acknowledging that M.I.T.'s aid policy is the pioneer, opening up ground that will soon be settled by all.

Financial Aid and Student Sources

M.I.T.'s stated goal is to maintain "diversity" in its undergraduate student body. But the Faculty Committee finds that in some respects this goal is in jeopardy: "Students from urban areas and especially from urban public high schools (excepting the Bronx High School of Science and a very few other special schools) are significantly under-represented. This disparity, thinks the Committee, probably has two sources: "financial differentials" between inner-city and suburban families, and "the comparatively low quality of the education available to students of most urban public high schools."

The Faculty Committee doubts that there has been any significant change in the diversity of M.I.T. students—in terms of their family incomes—in the last decade. Since 1960 the number of freshmen coming to the Institute from families in the lowest income quartile of the U.S. population with heads-of-families in the 44-54 age range has increased 3 per cent—from 7 per cent in 1961 to 10 per cent in 1971. In the same period the number coming from the highest quartile by family income has dropped 3 per cent (to 54 per cent); the fraction of students from the two middle quartiles has remained nearly constant (about one-third).

But an analysis of family income of M.I.T. entering students, made by *Technology Review* on the basis of Student Aid Center data, suggests that the profile of families sending students to the Institute may indeed be changing; the Student Aid Center data is based on $5,000 income steps, a finer screening than that cited by the Faculty Committee. The Student Aid Center data suggests that there may be significant changes in student services within the highest income quartile, that families with incomes over $17,250 in 1970 ($11,200 in 1964) may be increasingly less represented among M.I.T. students *(see chart, opposite).*

N. Nicholson

P. O. Roberts

(Continued from page 84)

Keil of the School of Engineering gave it a three-fold assignment:

☐ To foster research on transportation innovations, including especially those that involve integration of different travel modes.

☐ To stimulate broadly based research on transportation matters, including operation, management, economics, societal needs, planning, and environmental implications.

☐ To provide a base for a new graduate program in the School of Engineering which will emphasize systems and intermodal aspects of transportation.

Professor Roberts hopes the Center will be a point of focus for many teaching and research activities now underway in the transportation fields at M.I.T.—and he also hopes it can increase "the involvement of the outside world in the work going on here."

Six faculty members have been designated by Dean Keil as a steering committee to help the Director plan and operate the Center for Transportation Studies: Ernst G. Frankel, Mar.Mech.E. '60, Professor of Marine Systems; Ralph A. Gakenheimer, Associate Professor of Urban Studies; Herbert H. Richardson, '53, Professor of Mechanical Engineering; Robert W. Simpson, Ph.D.'64, Professor of Aeronautics and Astronautics; William C. Wheaton, Assistant Professor of Economics; and Zenon S. Zannetos, Ph.D.'59, Professor of Management.

The Acting Librarian Becomes the Librarian

Natalie Nicholson, whose experience with the administration of academic and research libraries has spanned 30 years, became Director of the M.I.T. Libraries on March 1; she had been Acting Director since the resignation last July 1 of William N. Locke, who is now Foreign Study Adviser in the Office of the Dean for Student Affairs.

Miss Nicholson was Associate Director of the Libraries from 1958 to 1972; she came to the Institute in 1954 from the post of Librarian at the Harvard Graduate School of Engineering.

Miss Nicholson says her emphasis as Director will be on developing "new information services tailored to individual users through applications of new technology;" and she will have a chance to begin that effort promptly with the incorporation of the James M. Barker Library (the engineering library) into the M.I.T. Libraries' administration during the

"In college there was Millikan for his elusive measure of the charge on the electron: mine was dandy—close to his!" a part of David McCord's memory of his one-time life in science, in the poem written by Mr. McCord to honor M.I.T.'s 1973 initiates into Phi Beta Kappa. The full poem is published elsewhere in this issue of the Review.

next six months.

The Barker Library has been operated under Project Intrex, a major experiment in computer-based information systems; Miss Nicholson believes that Intrex made "many innovative library service developments"—including rapid acquisitions of material, user-oriented catalog improvements, and modern microfilm services—and she hopes that "many of these services can be extended to other libraries at M.I.T."

As Director of Libraries, Miss Nicholson takes full responsibility for the collections—some 1.5 million books and periodicals—and the budget by which the Libraries are operated, over $3 million a year. Walter A. Rosenblith, Provost, says the Libraries play "a strategic role in underpinning improvements in the research and educational program of M.I.T.," and he said it was "particularly gratifying" to announce Miss Nicholson's appointment.

Advice to Scholars: Take a Job, Learn the Truth; Everything Connects

Not every Phi Beta Kappa orator—how many are there every spring across the U.S.?—has given his audience bright young intellectuals advice like this:

"Go out and do something as soon as you can. Find places that will let you put the things you have learned and the things that you feel together."

The point, said Elting E. Morison, Killian Professor of the Class of 1926 in the School of Humanities and Social Science, is that "everything connects." But "our means of educating ourselves," our intensive specialization "in the side roads of education have masked from us a general view of the whole. We have lost sight of how to synthesize, how to put together all the knowledge we have in order to give meaning to life."

Paraphrasing a famous statement of philosopher Alfred North Whitehead ("The nation that does not value the trained mind will perish."), Professor Morison told his Phi Beta Kappa audience that "the nation that misunderstands the role of the trained mind will also perish."

Earlier at the Phi Beta Kappa initiation dinner at the St. Botolph Club in Boston, poet David McCord, former Director of the Harvard College Fund, read the 40 lines which he dedicated to the 1973 Phi Beta Kappa initiates of M.I.T. The poem *(see page 79)* celebrated Mr. McCord's own adventures into "the edge of physics" as a radio operator and—much later—as a member of the Harvard community.

At least 70 members of M.I.T.'s Class of 1973 qualified for election into the M.I.T. chapter of the national society which is dedicated to excellence in the arts, sciences, and letters. By special arrangements with the national office, the 1973 initiates included a small number of students receiving degrees in management, architecture, and engineering—as well as the traditional fields of science and humanities. Admission of a few students from "the alien schools, regarded as backwashes by the national headquarters," said Professor E. Neal Hartley, President of the M.I.T. chapter, was in recognition of their accomplishments in the humanities and sciences as well as in the fields of their majors.

Speaking to the new Phi Beta Kappa members following their initiation, Professor Hartley warned that a "new wave of anti-elitism" threatens the scholarly traditions of recognizing and honoring excellence. But it is still true, thinks Professor Hartley, that "to know more is to give more," and he appealed to the new members of the society to share his—and its—concern for "the strength of the liberal arts" and "for excellence in intellectual pursuits."

Pass/Fail Becomes Pass/Internal Fail for Freshmen; But What Shall Grades Signify Anyway?

Pass/fail grading for freshmen began five years ago as a four-year experiment. Last year it was renewed for one year. This year's faculty action on the issue is again an interim measure to keep freshmen safe from letter grades. With it, the faculty has voted that a committee be established to study the entire matter of grading at M.I.T.

The interim solution for freshmen has four parts:

☐ A single passing grade—P—for subjects taken in the freshman year.

☐ "Internal fail"—freshman-year grades of F to be "recorded only for use within the Institute."

☐ A "hidden-grades policy"—the requirement that faculty members "identify outstanding work, report it to the student in terse, concrete terms, and keep a record on file" for five years, for the student's use if, for example, the student cares to tell medical schools about it.

Students who apply to medical schools often do so after three years or less of undergraduate education, so that freshman grades comprise a substantial portion of a student's academic record. Further, many premed students take organic chemistry—a subject of great importance to medical schools—in their freshman year. So a simple statement of "pass" has seemed inadequate to medical schools with intense competition for their relatively small entering classes. "In the visible future a hard-core of 50-odd students . . . will be hurt if they do not have these grades available," reported the ad hoc Pass/Fail Committee to the faculty. While some faculty opinion holds that the practice of hidden grades undermines the pass/fail grading system, "the students seem to have a more pragmatic view of it. . . . We feel that student opinion should be the deciding factor."

☐ A "credit limit"—a maximum of 60 units in the fall and 63 units in the spring—designed to establish "realistic upper bounds, if the student is to do justice to the separate subjects." While freedom to explore seems desirable in

the freshman year, it can be misused by students "spreading themselves too thin." The Pass/Fail Committee reported that "some feel that limiting the number of units is heavy-handed, but it has the virtues of simplicity and it gets the message across clearly." Pass/internal fail grading seemed to make a credit limit virtually mandatory. With internal-fail, students with bloated schedules might be tempted to leave them unchanged through the end of the term: passed courses would add academic units, and failures would leave no permanently visible penalties.

Professors teaching foreign languages were especially upset by the credit limit, which, leaving room for only a nine-unit elective, could prevent freshmen from taking language subjects—all 12-unit electives. Teachers of languages, said Assistant Professor Gordon Nelson, insist that their students drop any subjects in which they haven't performed well in the first two or three weeks. Why shouldn't all professors do something of the sort? It is easy to judge performance in subjects in which a foreign language must be mastered, replied Professor Arthur Mattuck (Mathematics), Chairman of the Pass/Fail Committee. Language instructors are in a fortunate position not shared by other departments.

A Review of All Grading

Even before the faculty debate on pass/internal fail, the Committee on Academic Performance had asked the Committee on Educational Policy for a special ad hoc committee "to consider possible changes in grading policies and procedures at M.I.T." The faculty having approved, the members of such a committee are to be named by the President and the Chairman of the Faculty, and the Committee is to report sometime next year.

The C.A.P. had observed what they termed an upward "infiltration" in grades; three-quarters of the grades currently assigned at M.I.T. are A's and B's. This trend, coupled with the diversity in grading practice among faculty members and the disparity between grading theory and practice, made the C.A.P.'s duty—monitoring academic matters—increasingly unfeasible.

A debate on grading often seems to be a debate on how to change the schedule of rewards and punishments in a college education. There is no lack of variables. They include:

☐ The grades themselves. Letters or pass/fail? How many different grades should there be? How exclusive should a high grade be? And how damning failure?

☐ How many units can a student register for each term? Is it a student's right to "overload"?

☐ How many units is each M.I.T. subject worth? Do these units accurately reflect the effort each subject requires? (It is, for example, widely held that computer courses tend to be underrated; they generally require far more commitment from students than the numbers of their units indicate.)

☐ How many units should be required for a degree?

You wanted a sit-down lawnmower on which you can get some exercise? Call Michael Shakespear, '73, who's just finished this pedal-powered model as his senior thesis in the Department of Mechanical Engineering. The project, he said, gave him "a solid realization of what is entailed in transforming a design concept into a reality." (Photo: Margo Foote)

☐ How late in a term should the "drop date" come? (The "drop date" is the day on which student schedules become unalterable; any subject for which a student is registered on that day must be taken to completion and a final grade.)

Margaret MacVicar, '64, Assistant Professor of Physics, told the faculty that the desire to tinker with grading and units seems to her to represent a failure on the part of faculty advisers; "it isn't the students who are being irresponsible," she said. Professor Nathan Sivin, '52, (humanities) criticized what he felt was a change in faculty advising from "approving a course [on a student's registration form] to taking notice of it."

Professor Mattuck responded that an adviser cannot be "judge, jury, and friend." If the adviser makes of himself "a roadblock between the student and what he feels are his legitimate rights at the Institute," the student becomes his "enemy."

Internal-Fail for Upperclassmen?

The freshman-year policies may provide more than an easing of the transition into college for freshmen. The use of a pass/internal-fail grading system for freshmen-year grades will provide data that may help the faculty judge new ideas for upperclass grading. The Committee on Educational Policy wrote in a statement to the faculty that "the grade F now appears to indicate, almost exclusively, that the student has neglected to drop a subject." It also appears that many professors now give C's "in circumstances that would formerly have yielded an F."

One possible remedy involves letter grades for passing performances but internal-fail and no credit for failure. This might remove the connotation of "permanent and public penalty" from the grade F and perhaps would encourage faculty to use the grade more often.

A Feasibility Study: Combine Utility and Exercise

Michael Shakespear, '73, wrote a senior thesis for the Department of Mechanical Engineering this spring on "A Project to Investigate the Feasibility of Combining Utility and Exercise."

Translated, that means building a riding lawnmower which uses the operator's pedal-power instead of an engine for locomotion.

On the surface that sounds easy: put a lawnmower on a boy's tricycle. But because the power source is limited, "efficiency has to be optimized and weight minimized," is how Mr. Shakespear explained it in his thesis; and because riders will pedal at different speeds, the cutter has to work equally well at high and low speeds.

Mr. Shakespear is not waiting for the world to beat a path to his door with

orders for a man-powered riding lawnmower. But he thinks the project was a "good learning experience." He discovered, for example, that it's "much easier to think abstractly about a differential than to machine one so that it does not bind."

Nineteen Faculty Retirements After 550 Years of Service

The exercise is traditional if irrelevant: the combined service on the M.I.T. faculty of the 19 members who retire on June 30 is 550 years. But the more important issue of their combined experience and wisdom gained during—in most cases—lifetime careers at M.I.T. remains unquantifiable.

It is the largest number of faculty retirees for any year in the 108-year history of the Institute.

Many of those retiring this year will continue on half-time appointments for the teaching and research to which they have devoted their lives.

The faculty members retiring this year:

☐ **Manson Benedict**, Ph.D.'35, Institute Professor and former Head of the Department of Nuclear Engineering, is one of the nation's leading authorities on the design and operation of nuclear reactors and a leader in nuclear engineering education. Born in Michigan, Professor Benedict studied chemistry at Cornell University (B.Chem. 1928) before coming to M.I.T. for graduate study. After many years in industry and at Harvard, Dr. Benedict returned to be Professsor of Nuclear Engineering at M.I.T. in 1951, responsible for developing a program of research and teaching which led to establishment of the Department of Nuclear Engineering in 1958. Dr. Benedict was Head of that Department from 1958 to 1971 and was named Institute Professor in 1969. Last year he received the Enrico Fermi Award from the Atomic Energy Commission for his outstanding contributions to the field.

☐ **Joseph Bicknell**, '34, Professor of Aeronautics and Astronautics and a specialist in applied aerodynamics, has been a member of the faculty for 30 years and of the Institute staff since 1934. He was an assistant in aeronautical engineering from 1934 to 1937 while completing his Master's degree, then became Research Associate and finally joined the faculty in 1943. Professor Bicknell was instrumental in developing the early programs in the Wright Brothers Wind Tunnel and was involved with aircraft testing in the wind tunnel during World War II. He served as Executive Officer of the Department and as Faculty Operations Officer for several years, and during 1968-69 he headed the Department's Experimental Projects Laboratory.

☐ **Gordon S. Brown**, '31, Institute Professor and Dugald C. Jackson Professor of Engineering, has been a pioneer in feedback control systems and in interdisciplinary approaches to large-scale technological problems. A native of Australia, Professor Brown came to M.I.T. as an undergraduate and continued for graduate study (S.M. 1934, Sc.D. 1938), working with such men as Vannevar Bush, '16, Harold L. Hazen, '24, and the late Norbert Wiener. He became Director of the Servomechanisms Laboratory shortly after joining the faculty in 1939, Head of the Department of Electrical Engineering in 1952, Dean of the School of Engineering in 1959, Jackson Professor in 1968, and Institute Professor this spring. Throughout his career Professor Brown has been a leader in educational innovation, most recently in developing a new role for M.I.T. in societally-based engineering.

☐ **Prescott D. Crout**, '29, Professor of Mathematics, has been a member of the teaching staff for nearly 40 years. Born in Columbus, Ohio, he came to M.I.T. as an undergraduate and continued for graduate study (S.M. 1929, Ph.D. 1930). During World War II Professor Crout was associated with the Radiation Laboratory, working on specific radar development problems and on theoretical investigations. He returned full time to the faculty in 1945 and has since concentrated his teaching in areas of analytical mathematics.

☐ **Albert G. H. Dietz**, '32, Professor of Building Engineering in the Department of Architecture, is a recognized authority on structures, construction materials, and construction management. He came to the Institute in 1930 after completing undergraduate work at Miami University (Ohio), studied for two M.I.T. degrees (S.B. 1932, Sc.D. 1941), and meanwhile taught structural engineering in the Department of Building Engineering and Construction. In 1953, Professor Dietz served for a year as Acting Head of the Department of Civil and Sanitary Engineering. From 1962 to 1967 he held a joint appointment in the Departments of Civil Engineering and Architecture.

☐ **Carl F. Floe**, Sc.D.'35, Professor of Metallurgy, began his career at Washington State University (B.S. 1930, M.S. 1932, then came to M.I.T. to complete his education. He taught at Washington State University and at the University of Notre Dame before returning to the Institute as a member of the faculty. He became Executive Officer of the Department of Metallurgy in 1943, in 1952 was called to the M.I.T. administration as Assistant Provost, and in 1956 became Assistant Chancellor. Dr. Floe served as Vice President for Research Administration from 1959 to 1969, when he asked to return to his faculty responsibilities.

☐ **George G. Harvey** is Academic Officer for the Department of Physics and Associate Director of the Research Laboratory of Electronics. A native of St. Louis, Dr. Harvey received the A.B., S.M. and Ph.D. degrees from Washington University, coming to M.I.T. in 1934 after two years as a National Research Council Fellow in physics at the University of Chicago. Dr. Harvey was appointed Assistant Director of R.L.E. in 1950 and Associate Director in 1953; he is best known for studies on x-ray scanning and atomic structure, and his work in electron microscopy resulted in the building of one of the first high resolution electron microscopes in this country.

☐ **August L. Hesselschwerdt, Jr.**, S.M.'34, a specialist in heat transfer, refrigeration, and air conditioning, has been a member of the mechanical engineering faculty since 1942. Following undergraduate (S.B. 1931) and graduate work at M.I.T., Professor Hesselschwerdt was from 1934 to 1936 an engineer with the York Ice Machinery Corp.; he then joined the mechanical engineering faculty at Wayne University, and he returned to M.I.T. as Assistant Professor of Mechanical Engineering in 1942. From 1951 to 1958 he also served as Visiting Lecturer at the Harvard Graduate School of Design. Professor Hesselschwerdt was an early proponent of solar energy for space heating and more recently has investigated its application to refrigeration. For many years he directed M.I.T.'s Refrigeration and Air Conditioning Laboratory.

☐ **John T. Howard**, M.C.P.'36, served for more than 12 years as Head of the Department of Urban Studies and Planning. He was born in Paris, and studied at Antioch College and Yale University, receiving the B.F.A. degree from the latter institution in 1934; he then came to M.I.T. for professional studies (B.Arch. 1935). Professor Howard was a research assistant for the New England Regional Planning Commission, a city planner for the Regional Association of Cleveland, and from 1942 to 1949 Planning Director of the City of Cleveland before returning to M.I.T. as Associate Professor of City Planning. He was named Professor and Head of the Department in 1957, serving in that position until 1970. In addition to his teaching, Professor Howard has been a consultant to dozens of American cities and towns.

☐ **Arthur T. Ippen** is Institute Professor and Director of the Parsons Laboratory for Water Resources and Hydrodynamics in the Department of Civil Engineering. An international authority on water resource engineering, Dr. Ippen has concentrated much of his work on the coastal environment. He was born in London, received the Diplom-Ingenieru degree from the Technical University of Aachen, Germany, and the Ph.D. in civil engineering from the California Institute of Technology in 1936. After two years in teaching and research at Caltech, Dr. Ippen joined the faculty at Lehigh University. He came to M.I.T. in 1945 as Associate Professor of Hydraulics and took charge of planning for the Institute's Hydrodynamics Laboratory which under his direction has grown to become a distinguished center for research in hydraulics and water resources. In 1965 he was appointed Ford Professor of Engineering and in 1970 Institute Professor.

☐ **Delbar P. Keily**, '34, Associate Professor of Meteorology, is a specialist in aircraft and meteorological instrumentation. A native of Hartford, Conn., Professor Keily was appointed a research assistant in meteorology in the Department of Aeronautical Engineering three years after completing undergraduate work at M.I.T. Later he served as an instructor in meteorology and in aeronautical engineering. In 1946 he transferred to the Department of Meteorology. Professor Keily has taught two of the basic undergraduate subjects in the Department as well as a graduate subject on instruments, and he has helped solve instrumentation problems in departmental re-

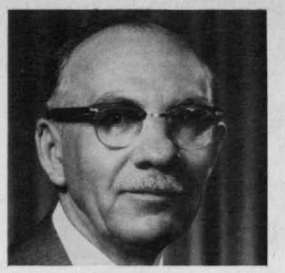
(Continued on p. 94)

Manson Benedict
Institute Professor;
Professor of Nuclear Engineering
Manson Benedict is one of the giants of nuclear technology and nuclear engineering education. He has demonstrated his versatility as the co-author of a leading text on nuclear chemical engineering, as a clear and persuasive teacher, and as the head of one of the finest nuclear engineering departments in the country. He has played a key role as a consultant in nuclear industry, carrying out numerous difficult tasks that required unbiased and competent handling. He served for ten years on the Atomic Energy Commission's Advisory Committee on Reactor Safeguards and for more than ten years on the Commission's General Advisory Committee, of which he served as Chairman for several years. During my tenure as Chairman of the A.E.C., we called on him over and over again.

Glenn T. Seaborg, Former Chairman,
U.S. Atomic Energy Commission

Prescott D. Crout, '29
Professor of Mathematics
Prescott Crout has been termed "the engineer's ideal of a mathematician. He speaks the language of engineering, but he uses the tools of mathematics." His direct approach to engineering problems and his skill in making mathematics work have been a source of great inspiration. When he encounters a scientific or engineering problem, if suitable mathematics is available, he uses it; if not, he has the capacity to create whatever mathematics is needed. Prescott Crout is well-known among numerical analysts for a method he devised, widely referred to as the Crout Method, for systematizing calculations in the solution of n simultaneous linear equations in n unknowns. By such innovations, and by his hard work and his expectations of it from others, Prescott Crout has significantly influenced the scientific work of generations of students.

William T. Martin
Professor of Mathematics



Joseph Bicknell, '34
Professor of Aeronautics and Astronautics
Joseph Bicknell is one of the foremost wind tunnel designers and experimental aerodynamiscists in the country. As such he has imparted a flavor to the educational program at M.I.T. which is truly unique. His many years of dedicated service in running the Wright Brothers Wind Tunnel, sometimes under very difficult and strenuous conditions, and his active interest in teaching some of the most basic courses in the Department will long be remembered.

Professor Bicknell laid the foundation for much of the work in applied aerodynamics in the Department; at the same time he served for many years as Executive Officer and was an active contributor in all phases of departmental life. His sage advice will be greatly missed.

Rene H. Miller
Head of the Department of Aeronautics and Astronautics

Albert G. H. Dietz, '32
Professor of Building Engineering
From the bygone days when Course XVII was Building Engineering and Construction and he was a young instructor showing his students how to set batter boards at the M.I.T. Summer Camp in East Machias, Maine, Al Dietz always demonstrated that extra-special-something that marked him as a teacher of a high order. Later, the Department of Civil and Sanitary Engineering was happy to have him join its faculty as an expert in areas such as timber and plastics; and later still, as his interests expanded into the many phases of building engineering in its broadest sense, Al transferred his talents to the Department of Architecture.

No one within the sphere of M.I.T.—at least within my recollection—has better personified that elusive combination of the architect's ability to synthesize and the analytical rigor of the engineer.

John B. Wilbur, '26
Consulting Professor of Engineering Emeritus

Gordon S. Brown, '31
Institute Professor; Dugald C. Jackson Professor of Engineering
Graduating as the depression deepened, Gordon S. Brown first joined the pioneers working on feedback control systems, precursors of a new age of automation. To this work he made extensive contributions of his own, and in 1941 he was among the founders and became the first Director of the Servomechanisms Laboratory, which was destined to play a unique role in the development of new ideas in the expanding field of servocontrol. In the years following World War II Gordon became increasingly preoccupied with basic shortcomings of engineering education. Never had the frontiers of technology moved forward so swiftly, and the education of the engineer was failing to keep pace. He was dismayed by what he viewed as a prevailing "academic atrophy," and characteristically he undertook to do something about it. As Head of the Department of Electrical Engineering he brought about revolutionary changes in curriculum and methods. And as Dean he continued these efforts to build new strength throughout the School of Engineering, becoming the eloquent spokesman for reform and innovation. His career has brought him recognition and honor throughout the world of engineering. To his courage, his determination, and to his inexhaustible energy we owe in no small part the preeminent position that M.I.T. holds today, both at home and abroad, in engineering education. But beyond all his professional accomplishments and underlying his many achievements in the field of education lies his thorough understanding of what this special institution of ours is all about—its aims and purposes, its early days, the changes of the intervening years. As a true systems analyst, he looks upon M.I.T. both as a dynamic whole and as a group of individuals whose efforts at every level are essential to the advancement of the Institute and in turn to its more effective contributions to the larger society.

Julius A. Stratton, '23
President Emeritus

Carl F. Floe, '35
Professor of Metallurgy
It was a severe shock to the Department of Metallurgy when Carl Floe was asked to join the M.I.T. administration in 1952; he had been Executive Officer of the Department almost since its inception, keeping us on the track with budgets and schedules and personnel relations and all the multitudinous concerns of an Executive Officer. In addition, he was an enthusiastic teacher and even his Vice-Presidential duties did not stop his teaching naval postgraduate students.

Dr. Floe's interests have centered around the structure of metals on a microscopic scale and the relation of structure to properties. Modern nitriding for production of abrasion-resistant surfaces follows the methods of the Floe Patents. He is a widely recognized authority on metal failure analysis; and his good sense and wide experience have made him a valuable member of several boards of directors.

John Chipman
Professor of Metallurgy, Emeritus

George G. Harvey
Professor of Physics
Physicist, classicist, scholar, and gentleman, George Harvey has brought to M.I.T. a devotion which can hardly be surpassed. Self-effacing by nature, his part in the revitalizing of science after World War II is known to only a few, but those few recognize the Institute's debt to George. The hallmark of his career has been service to science, to the Institute, and to his colleagues, and we who follow can best repay him by continuing such service.

Albert G. Hill
Professor of Physics

August L. Hesselschwerdt, '31
Professor of Mechanical Engineering
His generations of students can attest to his qualities as a teacher, and his associates who concern themselves with the operations of M.I.T. can also attest to his skill as a practicing engineer, where his efforts have resulted in significant economies and improved utilities operations. Both groups of August L. Hesselschwerdt's associates at M.I.T. have benefitted as well from his all-round good sense, good humor, and unassailable sense of fairness. All of these talents have been demonstrated together, for example, in his success as Chairman of the Committee on Parking; it is a job requiring fairness, common sense, diplomacy, and the wisdom of Solomon all wrapped into one package. His patience, understanding, firmness when called for, and basic humanity all contributed to his effectiveness in 40 years of everyday life at M.I.T.

Philip A. Stoddard, '40
Vice President, Operations

John T. Howard, '35
Professor of City and Regional Planning
John T. Howard agreed originally to serve only five years as Head of the Department of City and Regional Planning, but the commitment stretched into thirteen years. There were good reasons for this. He is not only very able and hard working: he is an extraordinarily decent and honest human being. Aside from his service to M.I.T., he has given many years of unstinting assistance to the American Institute of Planners of which he served as President and from whom he has received their Distinguished Service Award. Most important of all, Professor Howard has given a generation of students a view of the planner in action, stressing particularly the ethics of professional responsibility. He has always been held in the greatest affection and respect.

Lloyd Rodwin, Head of the Department of Urban Studies and Planning; and Kevin Lynch, '47, Professor of City Planning

Arthur T. Ippen
Institute Professor,
Professor of Civil Engineering
If I were asked whether his professional impact had been greatest locally, nationally, or internationally, I would be hard put to answer. Quite aside from an evident mastery of hydraulics, Arthur Ippen exerts an almost charismatic effect upon associates everywhere. At M.I.T. he has built the Parsons Laboratory from scratch into one of the top three or four such establishments in the country, if not the world. More than one American engineering society has felt his strong guidance in the fluids field. Germany bears many a mark of his pedagogical skill. And through wise leadership of the International Association for Hydraulic Research, Art has influenced the worldwide course of our profession probably as much as any other person.

Hunter Rouse, '29
Carver Professor of Hydraulics
University of Iowa

Delbar P. Kelly, '34
Associate Professor of Meteorology
Caught in the throes of the great depression, Delbar P. Keily worked as a shipboard radio operator until he had sufficient funds to enter the Institute, where he chose electrical engineering. Shortly after graduation he came under the influence of C. Stark Draper and became a member of the instrumentation group that was the precursor of the Draper Laboratory. When meteorology became a separate department he resolved to leave this instrumentation group in order to introduce students to the field of measurements and instrumentation. Though he frequently adopts the pose of a demanding taskmaster, closer contact reveals him as a warm and sympathetic counselor and friend who is always ready to help. He has served the Institute, professional societies, and his community in demanding but inconspicuous roles with seemingly boundless energy.

Henry G. Houghton, S.M.'27
Professor of Meteorology, Emeritus

Roy Lamson
Class of 1922 Professor
Professor of Literature
It was a good day for M.I.T. when Roy Lamson came to us from Williams College, first as a visitor but soon enough as a permanent member of our professorial ranks. A scholar, a wit, a man of enormous energy and high standards and uncommonly versatile (jazz clarinet to Bach), a man of great enthusiasms and insights about almost everything, one who was equally at home in the company of Julia Child, Kenneth Galbraith, Aldous Huxley, and the youngest student, he was both relaxed and civilized. He believes in decorum. He believes in academic discipline of the right sort—and he did so even when this was not generally fashionable. He directed Course XXI from the start and is now liaison between the President and the Art Council. He has done a great deal for us, and I am grateful for having been one of his friends.

John E. Burchard, '23
Dean of Humanities, Emeritus

Walter McKay, '34
Professor of Aeronautics and Astronautics
Walter McKay has been for many years one of the most dedicated faculty members of the Instrumentation, Guidance and Control Division of the Department of Aeronautics and Astronautics. Since before World War II he has brought to his students the practical flavor of the practicing engineer. Stern when he needed to be, he could also be very supporting and understanding to the student who needed help. From the days of testing simple flight instruments, such as the magnetic compass, Walt has been a mainstay through to the development of sophisticated automatic systems; and he has continually shared his experiences with his students.

Walter Wrigley, '34
Professor of Instrumentation and Astronautics

Herman P. Meissner, '29
Professor of Chemical Engineering
"Fritz" Meissner and the writer of this little comment were classmates in 1929, wrote a chemical engineering thesis together in 1930, and then spent a couple of glorious years together as roommates working in New York. When in 1932 Fritz returned to his second love, Cambridge and academia, industry was the loser, M.I.T. the gainer. But those who knew him best knew he was born to teach, and since then he has been an inspiration to generations of chemical engineers.

"Fritz" Meissner is a true product of the golden era of chemical engineering at M.I.T., the 1920s and 1930s. An authority on thermodynamics and author of books and numerous publications, he will be remembered nevertheless as a great teacher of the "Doc" Lewis mold.
His knowledge is a fount available in that warm and glowing way all of us remember in only one or two of our teachers.

Paul V. Keyser, Jr, '29, Former
Executive Vice President, Mobil Oil Co.

Robert K. Mueller, '32
Associate Professor of Aeronautics and Astronautics
Robert Mueller was among the most creative of all students in the Department of Aeronautical Engineering during the mid-1930s. He contributed to the theory of operating systems closed in complete loops with the functions of control and command, and he was among the first to develop computation and simulation for complex systems, foreshadowing the essential role of computers in all phases of aerospace.

Back at M.I.T. in the last quarter-century, Professor Mueller has invented the "Microsyn" for generating electrical signals from angle inputs and producing output torque related to electrical inputs. And his imaginative approaches in the field of control, navigation, and guidance have been valuable elements in the education of many students.
Charles S. Draper, '26
Institute Professor Emeritus; former President of the Charles Stark Draper Laboratory

William M. Murray, Sc.D.
Professor of Mechanical Engineering
Bill Murray can look back upon four decades of consistent, faithful and productive devotion to his chosen field—experimental stress analysis—which he enriched with contributions in theory and experiment undreamed of when he started his graduate work at M.I.T. in 1933. As a co-founder of the Society for Experimental Stress Analysis in 1943, and in his activities with many other groups, his name became a revered one in this field.

Without him the Department of Mechanical Engineering and the Institute as a whole would be much poorer not only on the professional side but particularly on the human side. His attitude to his fellow men and his human sympathy and love for coworkers and students represent the most precious of his enrichments of our environment.

C. Richard Soderberg
Dean of the School of Engineering, Emeritus

Carl F. J. Overhage
Professor of Engineering
Of all the endeavors—the Radiation Laboratory, Project Charles, Lincoln Laboratory, Intrex, the School of Engineering—through which Carl F. J. Overhage has made and left his mark, none stands out more importantly than his Directorship for seven years of Lincoln Laboratory. This was the critical transitional period following the disengagement of Lincoln's SAGE System responsibilities, and the Laboratory is immensely stronger for his wisdom and leadership in guiding it into new program areas.

Carl is ideally suited to lead and enrich a large university laboratory. His professional stature and dedication to excellence further enhanced Lincoln Laboratory's reputation as a foremost electronics laboratory dedicated to national security. He is a stimulating leader, always challenging his colleagues with his penetrating conversation and wit.

Gerald P. Dinneen
Director of Lincoln Laboratory

Laszlo Tisza
Professor of Physics
Laszlo Tisza occupies a unique place in the intellectual life of M.I.T. His theoretical work on superfluid helium (that remarkable quantum liquid), especially his two-fluid model, has influenced much research in low temperature physics over the years. But these studies—and others on critical points, phase transitions, and fluctuations—must be seen as part of a broader program. For Tisza approaches science as a natural philosopher; his work combines a search for logical clarity with a full recognition of the richness, variety, and complexity of the experimental materials. As one of the "happy few" who had the opportunity to work closely with Laci Tisza on a doctoral thesis, I know the stimulating and liberating influence he exerts on colleagues and students.

Martin J. Klein, Ph.D. '48
Professor of the History of Physics
Yale University

John G. Trump, Sc.D.'33
Professor of Electrical Engineering
Following his graduate work as Robert J. Van de Graaff's first student, John started the High Voltage Research Laboratory and began its program on the generation and control of high voltages and of penetrating radiations. The industrial successes which resulted are well known—High Voltage Engineering Corp. was established through his initiative, originally to furnish supervoltage therapy equipment to hospitals and clinics. Less well known to his Institute colleagues is John's reputation among the medical profession and the clinical program in his laboratory where almost 10,000 patients have been treated.

John Trump's career at the Institute is a model of how a creative engineer in an academic environment can pioneer in the development of a new technology and in its applications to a wide range of human needs.

William W. Buechner, '35
Professor of Physics

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search in both meteorology and oceanography.

☐ **Roy Lamson**, the Class of 1922 Professor of Literature in the Department of Humanities, is Director of the undergraduate Humanities majors and Special Assistant to the President on the Arts. Professor Lamson came to the Institute as Visiting Professor in 1957 and was appointed Professor of Literature the following year. A native of New Haven, Conn., he received the A.B. in 1929, the A.M. in 1930 and the Ph.D in 1936, all from Harvard. Before coming to M.I.T., he had been Professor of English and Dean of Freshmen at Williams College, where he served for nearly 20 years. Professor Lamson's special interests lie in the English Renaissance, and he has written extensively on ballads and 17th-century music. In addition to his other responsibilities, Professor Lamson has served as chairman of the Northeastern Regional Committee for Marshall Scholarships, for which service he was appointed an Honorary Officer of the Order of the British Empire by Queen Elizabeth II in 1969.

☐ **Walter McKay**, S.B.'34, Professor of Aeronautics and Astronautics, has spent his entire professional career at M.I.T as student and teacher in the fields of instrumentation and guidance. Professor McKay, having completed bachelor's and master's degrees (1935) at the Institute, joined the faculty in 1941. He was in charge of the Department's Instrumentation division for several years and has served as Chairman of the Undergraduate Committee of the Department and as Executive Officer.

☐ **Herman P. Meissner**, '29, a leading authority on industrial chemistry, is the Lammot du Pont Professor of Chemical Engineering. Professor Meissner received his Sc.D. degree in 1938 from the University of Frankfurt am Main, Germany, after taking his S.B. and S.M. (1930) degrees at M.I.T. After graduating from M.I.T. Dr. Meissner served as Assistant to the Vice President for Research and Development of Commercial Solvants Corp., then returned to the Institute in 1932 on a du Pont Fellowship in the Department of Business and Engineering Administration. From 1934 to 1936 he was an instructor in marketing. After completing his doctorate, Professor Meissner joined the Department of Chemical Engineering, becoming Professor in 1951 and du Pont Professor in 1970.

☐ **Robert K. Mueller**, Sc.D.'36, Associate Professor of Aeronautics and Astronautics, has specialized in instrumentation and has served as a consultant to the Draper Laboratory for many years. Born in Waterbury, Conn., Dr. Mueller received his undergraduate and graduate (S.M. 1934, Sc.D. 1936) degrees from M.I.T., then worked for several aircraft companies before returning to the Institute as a research associate in 1943 joining the faculty in 1946. In addition to his teaching responsibilities, Professor Mueller has been a member of the Industrial Liaison Committee and of the Graduate Committee in the Department of Aeronautics and Astronautics.

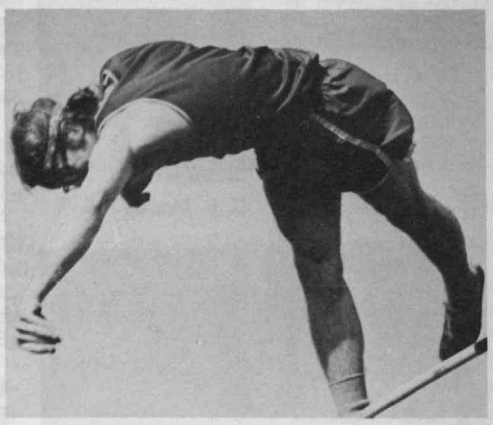
☐ **William M. Murray**, Sc.D.'36, Professor of Mechanical Engineering, is one of the leading American scientists in the field of stress analysis and nondestructive testing. A native of Canada, he came to the U.S. after graduating from McGill University (B.Eng.) in 1932 to attend M.I.T., where he received two graduate degrees; he was a member of the instructing staff even before completing graduate study, and he has continued teaching at M.I.T. ever since, joining the faculty in 1940. In the meantime he has been active in consulting and in professional societies, and he is widely known for a series of short courses in strain gage techniques and other nondestructive testing methods given throughout the U.S.

☐ **Carl F. J. Overhage** is Professor of Engineering, Director of Project Intrex, and Executive Director of the University Information Technology Corp.; he first won distinction at M.I.T. as Director of Lincoln Laboratory from 1957 to 1964. A native of London, Professor Overhage studied at the California Institute of Technology (B.S. 1931, M.S. 1935, Ph.D. 1937), and he first came to M.I.T. as a group leader at the radiation Laboratory during World War II. From 1946 to 1951 he was associated with Eastman Kodak Co., then returned to be among the first staff members at Lincoln Laboratory when it was formed. In 1964 Dr. Overhage relinquished his duties at Lincoln to initiate Project Intrex, a study of new information transfer technology in university libraries as Professor of Engineering; in 1968 he was appointed to the U.N.I.T.E.L. post.

☐ **Laszlo Tisza**, Professor of Physics, is a distinguished theoretical physicist in the fields of thermodynamics and quantum mechanics. He was born in Budapest, studied at the Universities of Budapest (Ph.D. 1932), Goettingen, and Leipzig, and worked on research at the Ukrainian Physico-Technical Institute in Kharkov and at the College de France in Paris before coming to the United States in 1941 to join the M.I.T. teaching staff, where he has won recognition as a teacher as well as for research and publications.

☐ **John G. Trump**, Sc.D.'33, Professor of Electrical Engineering and Director of the High Voltage Research Laboratory, is a pioneer in the design and applications of Van de Graaff generators. Born in New York City, Professor Trump received the B.S. degree (1929) from the Polytechnic Institute of Brooklyn and the M.A. (1931) from Columbia University before coming to M.I.T. for advanced work. He became a research associate, working with Robert J. Van de Graaff, then Professor of Physics, whose name is given to the electrostatic generator which he invented. Dr. Trump joined the faculty in 1936, and his career since then has been devoted to developing and exploiting the Van de Graaff generator including its use for treating malignant disease and for medical research, and to high-voltage insulation problems. In 1940 Professor Trump became technical aide to President Karl T. Compton who was then Chairman of the Radar Division of the National Defense Research Committee.

Highlights of spring sports 1973: Women's crew will have varsity status next year, but the girls will still be borrowing a shell from the lightweight men's team. (Does it make a difference? Read the adjoining column.) And it was a bad day for Bowdoin when its track team came to M.I.T.: Gary "Sugar Bear" Wilkes, '74, won the 100-yard dash, and the invincible David R. Wilson, '73, won the pole vault. (Photos: David H. Green, '75, and Fred H. Hutchison, '75)



Athletics: You Don't Have to Win, and We Proved It

Ross H. Smith, Director of Athletics, had a bit of trouble: the usual problems of foot-in-mouth disease that afflict any toastmaster unused to the assignment, and the fact that—he admitted it—1972-73 was "not the most outstanding year in terms of prowess" for athletics at M.I.T.

"We usually win more contests than we lose," he said in opening the Athletic Banquet for nearly 300 undergraduates and their coaches and sponsors this spring. "Not so this year," he admitted. But there was no pall of gloom.

Jerome H. Holland, former U.S. Ambassador to Sweden, was a football star at Cornell University in his college days and now is a member of the Football Hall of Fame: "Anyone who has been in intercollegiate athletics knows that you don't win them all, that you cannot be discouraged." You also learn, he said, to be "a responsible citizen, to make meaningful judgments, to understand the value of discipline." For him, said Dr. Holland, intercollegiate athletics were "a meaningful, integral part of the total educational experience," and he promised his student audience that they, too, would find their experiences making "the difference between doing a successful job and doing a job on which you can look back and say, 'I did the very best that I can do.' "

There were apparently plenty of performances in Mr. Holland's category of "best." Recognizing the year's "most valuable players" and giving "straight T" awards to M.I.T. athletes achieving national or regional recognition, Professor Smith's citations included:

☐ A four-oared shell rowed by Andrew W. Kernohan, '74, Gregory C. Chisholm, '73, Dustin P. Ordway, '73, and Jere B. Leffler, '73, with James E. Clark, '74 as cox, won in its class in the Head of the Charles Regatta last fall—"as fine a competition as any in the U.S.," said Professor Smith.

☐ The pistol team accumulated an 11-1 record in the Northeastern Collegiate Pistol League and was first among 29 competitors in the Greater Boston Pistol League.

☐ Two stars made the tennis team "one of the happier surprises of the year:" William D. Young, '74, and Leroy E. Simpson, Jr. '75, brought both singles and doubles New England Intercollegiate Championships to M.I.T., the first time both prizes have gone to a single school.

☐ The soccer team had its best record in eight years, losing the Greater Boston Soccer League championship only in a play-off to Tufts at the end of the season.

☐ Water polo, a newcomer among varsity sports at M.I.T., placed third in New England.

☐ Jerry L. Hudson, '73, graduated from M.I.T. in June the fifth basketball player in M.I.T. history to have made more than 1,000 points in his varsity career.

☐ The men's sailing team remains ranked as number two in the U.S.

Then there was the lacrosse team—"a perfect record in reverse," said Professor Smith. And some other frustrations. Women's crew, which will have varsity status next year, still lacks a shell of its own and must row the men's lightweight shells. Does it make a difference? Yes—the seats in those boats are simply too narrow. Viva la difference!

Farnham Retires and Reminisces: "I'll Name Every Kid . . ."

After 16 years as M.I.T.'s Head Coach of Indoor and Outdoor Track and Cross-Country, Arthur E. Farnham, Jr., retired in June. At age 50, he'll devote full time to the boys' camp in Orleans, Mass., of which he's a part owner.

But Art Farnham will never forget track, or M.I.T. "I'll stay close to track," he told Bob Monahan of the *Boston Globe*. "I love it. And despite what too many say, track isn't dying. More kids are running today than ever. And you better believe I intend to promote track every chance I get."

During Art's 16 years at M.I.T. his teams have won the Eastern track championship twice and the IC4A college division meet once. Because M.I.T. doesn't recruit athletes, Art Farnham explained to Mr. Monahan, "we don't know what we'll have for athletes until after they have been accepted." Then he started a long reminiscence, naming his favorite runners, jumpers, and vaulters. "But I'd better stop," he finally said. "I'll name every kid I ever coached."

Innovation in Structures? It Ended in 1914

There is nothing new under the sun—at least in aircraft structures.

That was the message around which Nicholas J. Hoff, former Head of the Department of Aeronautics and Astronautics at Stanford University, built the fourteenth Lester D. Gardner Lecture on May 11.

In the eight years between the first flight of a heavier-than-air craft in Europe (1906) and the start of World War I (1914), "almost every new solution in aeronautical structures were tried out," he said. Even today the work in this field is little more than "modification and extension" of that early work, he said.

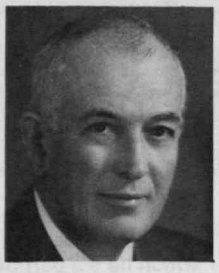
For example:

☐ A retractable landing gear was first used in 1909—on a plane whose maxi-

A. N. MacDonald

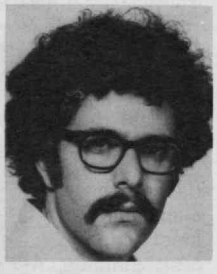
C. B. McCoy

E. C. Patterson



J. E. Turner

E. O. Vetter



L. Storch

F. R. Milliken

G. Smith

mum speed was 20 m.p.h., far too slow to have its aerodynamics changed by this unconventional feature.

☐ In the beginning all aircraft builders assumed that thin wings would be better than thick ones—less drag, lighter weight. Thin wings continued to be exploited by aircraft designers through the 1930s; but in the meantime thick wings were found to be aerodynamically satisfactory and structurally superior just as World War I began.

☐ The first fuselage using a monocoque structure—a thin, stressed skin on simple ribs—was designed in 1910; and that plane proved its strength and aerodynamic superiority by flying at a record 110 m.p.h. in that same year. Since then, and even in today's jets, this has become the standard aircraft structural system.

The Gardner Lectures are made possible by a bequest of the late Lester D. Gardner ('98), designated for annual lectures in the history of aviation. Before his death in 1956, Mr. Gardner—who was publisher of *Aviation and Aeronautical Engineering* for more than 10 years—also was instrumental in establishing the Hunsaker Professorship in Aeronautical Engineering at the Institute.

The Corporation Elects Five and Re-elects Three

Five new members—including three nominated by the M.I.T. Alumni Association—have been elected to the M.I.T. Corporation, and three former Corporation members have been re-elected.

The new members are:

☐ **Angus N. MacDonald**, '46, President of Angus MacDonald and Co., Inc., Stamford, Conn.

☐ **Charles B. McCoy**, S.M.'32, Chairman of the Board of Directors of E. I. du Pont de Nemours and Co.

☐ **Ellmore C. Patterson**, Chairman of the Board of Morgan Guaranty Trust Co.

☐ **James E. Turner**, '33, former Group Vice President, Textron, Inc.

☐ **Edward O. Vetter**, '42, Executive Vice President, Texas Instruments, Inc.

Laurence Storch, '71, a student at Harvard Law School, was elected to a five-year Corporation term as a Representative from Recent Classes. Mr. Storch previously served a one-year term in 1971-72 when the Representative from Recent Classes membership category was first established.

Two alumni were re-elected to five-year term memberships:

☐ **Frank R. Milliken**, '34, President and Chief Executive Officer of Kennecott Copper Corp.

☐ **Gregory Smith**, '30, former President and General Manager of Eastman Gelatin Corp., Peabody, Mass.

In addition, **William S. Edgerly**, '49, Financial Vice President of Cabot Corp., has begun a one-year term as ex-officio Corporation member by virtue of his election as President of the M.I.T. Alumni Association, concurrent with his five-year term as a Corporation member which began in 1971.

Mr. MacDonald holds two M.I.T. degrees, the S.B. in aeronautics and astronautics and the S.M. in mechanical engineering (1946), and he has made his career in management consulting since that time. Active in M.I.T. affairs, he has been a member of the Corporation Development Committee and an officer of the M.I.T. Alumni Center of New York, the M.I.T. Council for the Arts, and the Alumni Association.

Mr. McCoy came to M.I.T. from the University of Virginia and joined the du Pont Co. immediately upon completing his graduate studies, becoming Vice President in 1961, President and Chairman of the Executive Committee in 1967, and Director and Chairman of the Board in 1971. He is a member of the M.I.T. Corporation Development Committee and of the Visiting Committee for the Department of Chemical Engineering.

Mr. Patterson came to the Morgan Guaranty Trust Co. through its merger with J. P. Morgan and Co. in 1959; he had joined J. P. Morgan upon graduation from the University of Chicago in 1935 and became a Vice President in 1951. He was President of Morgan Guaranty from 1969 to 1971, when he assumed his present post.

Prior to its merger with Textron, Inc., Mr. Turner was Vice President for Finance and Administration of Talon, Inc., the firm which he joined shortly after graduating from the Harvard Business School in 1935. He became Talon's Treasurer in 1944.

Mr. Vetter's career in the petroleum industry began in 1946, when he joined Standard Oil Co. (California) following service in World War II. By 1952 he was with Geophysical Service, Inc., a subsidiary of Texas Instruments, Inc., and he served as Geophysical Services' President from 1966 until taking his present post in 1972. Mr. Vetter has been a member of the Corporation Development Committee and its Visiting Committee for the Division of Sponsored Research, and he has been active in alumni affairs including service as President of the M.I.T. Club of Dallas.

Physics: From Weisskopf to Feshbach

Herman Feshbach, Ph.D.'42, who has directed the Center for Theoretical Physics since 1967, will become Head of the Department of Physics on July 1; he will succeed Victor F. Weisskopf, who wants to spend the last year before his retirement in full-time teaching and research.

In his announcement of the change, Robert A. Alberty, Dean of the School of Science, called attention to Professor Weisskopf's "distinguished leadership of the Department" since he became its Head in 1967. Professor Weisskopf is in fact recognized as one of the leaders of American physics, and M.I.T.'s department as "one of the strongest in the world," in Dean Alberty's words.

Professor Feshbach began teaching physics at M.I.T. before he finished his Ph.D. degree, and his first appointment to the faculty, as Assistant Professor of Physics, came in 1945. Since then he has become increasingly recognized for research and writing in theoretical physics, and in April he received the Tom W. Bonner Prize of the American

Physical Society for contributions to the theory of nuclear reactions.

Professor Feshbach has spent two years—1954-55 and 1962-63—at CERN, the European center for nuclear research, while on leave from M.I.T., and he has also served at Brookhaven National Laboratory, Los Alamos Scientific Laboratory, and Oak Ridge National Laboratory. His book (with Professor Philip M. Morse) on *Methods of Theoretical Physics* is considered a basic text in the field, and he is now completing, with Professor A. de Shalit, *Fundamentals of Nuclear Theory*.

High-Energy Physics: New Directors for L.N.S., Bates

Peter T. Demos, Ph.D.'51, has been associated with the management of M.I.T.'s Laboratory for Nuclear Science for 21 years—almost since its founding. Now he has left that set of problems to Professor Martin Deutsch, '37, who becomes new Director of L.N.S., and Dr. Demos himself becomes Director of M.I.T.'s new Bates Linear Accelerator in Middleton, Mass.

L.N.S., one of the Institute's first interdepartmental laboratories, is a focus for basic research in nuclear physics. It operates the Bates Accelerator and a large computer facility on the campus as well as other activities to support research on high-energy machines at Brookhaven and Argonne National Laboratories, the Stanford Linear Accelerator, the National Accelerator Laboratory, and the German high-energy electron synchrotron at Hamburg—a total budget of over $6 million a year.

Professor Deutsch's work in elementary particle physics is widely known; he was the first to discover positronium (in 1951) and has since determined many of its properties. He is a long-time Chairman of the L.N.S. Steering Committee.

Professor Deutsch came from Vienna to the U.S. in 1935—and to M.I.T. in the same year; and he has been at the Institute ever since. He joined the teaching staff following graduate work (Ph.D. 1941) and became a member of the faculty in 1945. On leave from the Institute, he was at Los Alamos, N. Mex., from 1944 to 1946 and has held Guggenheim Fellowships in 1953-54 and 1960-61.

Dr. Demos came to M.I.T. as a graduate student at the end of World War II, having studied at Queens University, Ontario (B.Sc. 1941) and worked on ballistics for the Canadian National Research Council and Armaments Research and Development Establishment. He was Associate Director of L.N.S. from 1952 to 1961—and in that year he became Professor of Physics as well as Director of the Laboratory. He was for nine years beginning in 1960 a member of the Board of Trustees of Associated Universities, Inc., the university-sponsored organization which operates Brookhaven National Laboratory.

Appointments: Graduate School, Sea Grant, Development, News, Personnel, Alumni, Space

New assignments in the administration came to nine people during the spring:

☐ **Charles H. Ball**, former City Editor of the *Boston Herald-American*, joined the M.I.T. News Office as Assistant Director in March. He had been with the *Boston Herald-Traveller* as reporter, feature writer, and aviation writer since 1958; and he moved to the *Herald-American* when the *Herald-Traveller* and *Record-American* were joined by the latter's purchase of the former. A graduate of Boston University, Mr. Ball studied at the Columbia Graduate School of Journalism.

☐ **Lawrence E. Beckley**, '42, Administrative Officer of the Center for Space Research since 1963—almost since its founding—is now the Center's Assistant Director; accordingly, he has added responsibilities for administration of the Center's many programs. Mr. Beckley's M.I.T. career spans nearly 31 years of administrative work in the Aeroelastic and Structures Laboratory, the Division of Sponsored Research, the Draper Laboratory, and the Aerospace Research Division of the Department of Aeronautics and Astronautics.

☐ **Ira Dyer**, '49, Head of the Department of Ocean Engineering, has been named Director of the M.I.T. Sea Grant Program, effective July 1. In the new post he succeeds Alfred A. H. Keil, Dean of the School of Engineering.

As Sea Grant Program Director, Dr. Dyer will manage a wide range of ocean-related teaching and research programs supported at M.I.T. by the National Office of Sea Grant—and also a series of advisory services concerned with marine problems of the New England region.

☐ **Myer M. Kessler**, '39, is now Coordinator of Technical Data Systems in M.I.T.'s Information Processing Services; an expert on the use of computers in libraries, he has been Associate Director of the M.I.T. Libraries since 1965. He'll continue in his new post the same concern for machine-readable data bases for the M.I.T. Libraries, and he will also work on behalf of M.I.T. in a new Northeast Academic Sciences Information Center—a project of the New England Board of Higher Education funded by the National Science Foundation. Dr. Kessler joined Lincoln Laboratory in 1952 after several years teaching physics at Brandeis University.

☐ **James M. Kyed**, Associate Head in 1971-72 and Acting Head since 1972 of the Engineering Libraries, has now been named to direct the Barker Library as it returns from the administration of Project Intrex to that of the M.I.T. Libraries. Mr. Kyed first joined the M.I.T. Libraries in 1964 while he was enrolled for the M.S. degree in library science (1965) at Simmons College; he graduated in physics from Bates College in 1958.

☐ **James W. Lambert**, who has been Associate Director of the Development Office, has been named its Director; he succeeds Nelson C. Lees, '53, who earlier this spring was advanced to the post of Director of Resource Planning.

Mr. Lambert came to the M.I.T. Development Office in 1969 from the University of Southern California, where he was Director of Planning in the School of Engineering. He studied at Pennsylvania State University (B.A. 1957) and

H. Feshbach

P. T. Demos

M. Deutsch

C. H. Ball

L. E. Beckley

I. Dyer

M. M. Kessler

J. W. Lambert

J. J. Martori

J. Richard

has had experience as a lecturer presenting educational science programs in schools throughout the U.S. and Canada.

☐ **Joseph J. Martori**, whose logistical support for the Class of 1948 25th reunion at M.I.T. in June earned him an honorary membership in the Class, has been named Director for Alumni Services of the M.I.T. Alumni Association.

Mr. Martori is already Circulation Director of *Technology Review and* manager of personnel, and information systems, and financial records for the Alumni Association. With his new title, he will add logistical and administrative support for all Alumni Association functions—including class reunions.

☐ **Jeanne Richard**, Administrative Assistant in the Graduate School office, has been named to the new post of Assistant Dean of the Graduate School; she will have "special responsibilities for women graduate students," says Irwin W. Sizer, Dean of the School.

Describing her new assignment, Dean Richard says she hopes to help attract more women to M.I.T. for graduate study and "to make this campus a more attractive place for their education." Two specific goals are more fellowships for women who want to undertake graduate study and special arrangements for light class loads for mothers of young children.

☐ **Robert K. Weatherall**, Director of Career Counseling and Placement, has been named Acting Director of Personnel Development. It is a temporary appointment to assure that M.I.T. can proceed at once with its plans "to increase career opportunities and personal development" for Institute employees, according to John M. Wynne, Vice President—Administration and Personnel. The search continues, Mr. Wynne said, for a highly qualified person to devote full time to personnel development work for the Institute.

How to Divide $67,280 Among 28 Impoverished Student Activities

The Finance Board of the Undergraduate Association has allocated $67,280 to student activities for the 1973-74 year—some 6 per cent less than the 1972-73 total.

A new budget feature is an Activities Competition Fund, which at $6,750 will pay travel expenses incurred by student groups travelling to tournaments and competitions. The Debate Society will be the chief benefactor—$4,700—and the Chess Club is in for $1,200.

The largest single budget allocation for 1973-74 is to WTBS—$7,000. The station had asked for $19,664 to cover the cost of new equipment with which to expand the station's audience and services; but Finance Board appropriations are for operations, not capital improvements, and WTBS will have to look to the Activities Development Board for the latter.

Other big cuts from requested grants were handed to the African Students' Association and the Chinese Students' Club; both have restricted memberships, and the Finance Board by policy does not make major grants to such groups, said one of its members, Robert M. Elkin, '73,

	1972-73 grant	*1973-74 request*	*1973-74 budget allocation*
African Students' Association	$ 300	$ 3,600	$ 600
Automobile Club	—	1,720	100
Bridge Club	—	350	350
Chess Club	1,200	1,200	1,200
Chinese Students' Club	200	1,465	200
Committee for the Right to Choose	—	360	310
Dance Workshop	370	375	375
Debate Society	6,850	7,715	5,500
Ecology Action	150	450	450
Electronics Research Society	75	580	430
Pershing Rifles	—	150	150
Plant Club	—	261	50
Rocket Society	700	700	700
Science Fiction Society	800	800	250
Soaring Association	—	2,000	—
Strategic Games Society	115	160	120
Student Committee on Educational Policy	250	450	—
Student Information Processing Board	1,740	1,500	1,500
Technology Community Association	7,725	7,535	7,535
Tiddlywinks Association	450	450	450
Tropical Plant Club	125	75	75
Undergraduate Association	$10,945	10,800	10,800
Finance Board	12,675	14,250	14,250
Association of Student Activities	925	900	900
Secretary General	300	—	—
Nominations Committee	100	1,008	830
Urban Action	2,575	4,000	4,000
WTBS	5,000	19,664	7,000

The Undergraduate Association Finance Board has completed allocating all but $9,000 of the $67,280 available for undergraduate activities in 1973-74. The total represents a 6 per cent decrease from 1972-73, and most activities have taken small reductions because of the Finance Board's reduced expectations.

explaining the cuts to *The Tech.* The Soaring Association asked for $2,000 "to overcome a cash liquidity problem," and the Finance Board replied by recommending instead that the organization apply for a no-interest loan.

The largest increase went to Urban Action, the student activity concerned with helping underprivileged groups in Cambridge and Boston. With $2,575 this year, Urban Action asked for—and received—$4,000 for 1973-74.

Just over $9,000 of the Finance Board's funds remain unallocated.

Votes Counted; Edgerly Wins—the New Association Officers

William S. Edgerly, '49, Financial Vice President of Cabot Corp., is the President of the M.I.T. Alumni Association.

The announcement should startle few alumni, for Mr. Edgerly was unopposed in the national election for 1973-74 officers conducted by mail ballot during the spring.

Two Vice Presidents of the Association were chosen—by small margins—from a slate of four candidates offered by the Nominating Committee; both will serve two-year terms, effective July 1:

☐ **Susan E. Schur**, '60, President of Susan E. Schur (Adv.)

☐ **Hugh W. Schwarz**, S.M.'42, Vice President and Director of Corporate Planning, the Coca-Cola Co.

Similarly small margins were involved in the choice of five nominees—one for each of five districts—from ten candidates for members of the Association's Board of Directors for two years, effective July 1:

☐ **Carroll J. Brown**, S.M.'46 (District 3), Organization Planning Adviser, Exxon Corp.

☐ **Paul L. Hotte**, '42 (District 6), Vice President—Corporate Development, P. R. Mallory and Co., and Vice President of P. R. Mallory International, Inc.

☐ **Gordon T. Yamada**, S.M.'62 (District 7), Chief—Management Systems, Office of Management and Budget, Executive Office of the President.

☐ **Robert L. Rorschach**, '43 (District 8), Vice President and Treasurer of Data Systems Corp.

☐ **James W. Barton**, '39 (District 9), Director of Operations, Boeing International Corp.

Four alumni, representing three districts, have been chosen to serve on the National Nominating Committee for the 1974 elections:

☐ **D. Reid Weedon, Jr.**, '41 (District 1), Senior Vice President, Arthur D. Little, Inc. (Mr. Weedon will be Chairman of the Committee.)

☐ **George J. Schwartz**, '42 (District 1), President of George J. Schwartz and Associates.

☐ **William S. Richardson**, '44 (District 2), President, Watermarked Papers Co.

☐ **Robert Crane**, '48 (District 4), President, Crane Bio-Medical Instruments, Inc.

Mr. Edgerly has been a member of the M.I.T. Corporation since 1970 and has a long record of service to the Alumni Association (Vice President, 1966-68) and to the M.I.T. Corporation through its Visiting Committees. He was Chairman of the

Alumni Advisory Committee to the Commission on M.I.T. Education in 1970. Prominent in the Boston industrial community, Mr. Edgerly is a Director of the State Street Bank and Trust Co., Boston Manufacturers Mutual Insurance Co., and Mutual Boiler and Machinery Co.; he is also a member of the Executive Council of the Harvard Business School Association.

Miss Schur's outstanding achievement for M.I.T. has been her chairmanship of the Centennial Convocation sponsored this June by the Association of M.I.T. Alumnae, of which she is President; she has also been active in the M.I.T. Club of Boston and in alumni seminar activities. Her accomplishments as an artist are well known in the greater Boston area.

Mr. Schwarz' M.I.T. activities have centered in the M.I.T. Club of Atlanta (President, 1971-72), the Corporation Development Committee and Visiting Committee for the Department of Nutrition and Food Science, and the Educational Council. Before taking his present post in Atlanta, Mr. Schwarz was associated with the Minute Maid Co. and subsidiaries in Orlando, Fla.

After graduating from M.I.T., Mr. Brown joined the teaching staff of the Sloan School of Management, which he left in 1955 for management development and planning assignments with the Singer Co., Mobil Oil Co., and Exxon Corp., his present employer. His alumni activities have been in support of the M.I.T. Alumni Center of New York, of which he is Treasurer and for which he has served as chairman of several meetings and events.

Now a member of its Board of Directors, Mr. Hotte has a long record of service to the American Management Association; he is also a member of the Indiana Scientific and Engineering Foundation and a number of professional and scientific societies. He is "Mr. M.I.T." in Indianapolis, and he has been a member of the Alumni Fund Board and now of the Corporation Visiting Committee for Sponsored Research.

Before taking his present post, Mr. Yamada was responsible for work on data automation in the Headquarters of the U.S. Air Force. He has a long record of service to professional societies in civil administration and in military affairs, and he has been a major factor in the M.I.T. Club of Washington since first joining its Board of Directors in 1967.

Mr. Rorschach is deeply involved in professional chemical engineering programs in Tulsa, including air pollution control, and has held important assignments for the M.I.T. Club of Oklahoma. He is now a member of the Association's Club Advisory Board.

A New Leader for the American Academy, Rome: Henry A. Millon

The American Academy in Rome, which Nora E. Taylor of the *Christian Science Monitor* thinks represents "one of the most distinguished gatherings of artistic accomplishment extant," has a new Director: Henry A. Millon, Professor of the History of Architecture at M.I.T.

Professor Millon has arranged a three-year leave of absence from M.I.T. to take up his duties in Rome during the summer. He will serve as adviser for an architectural design studio which M.I.T. hopes to open in Italy for American architectural students. There is talk of a student group in Rome during the Independent Activities Period beginning next year, and Professor Millon is planning an M.I.T. summer subject in Rome for architects and art historians.

But Professor Millon's principal assignment will be as Director of the illustrious American Academy, which is designed to provide a stimulating environment for an outstandingly creative group of artists in residence each year. He will maintain the Academy's resident staff, help select the distinguished visitors who come to Rome, and will oversee their comfort and convenience; among the visitors this year are the poet John Ciardi and musicians Elliot Carter, Lukas Foss, and Randall Thompson.

Another assignment for the Director, thinks Professor Millon, is "to provide leadership by his own actions as to what the level of scholarship should be" at the Academy.

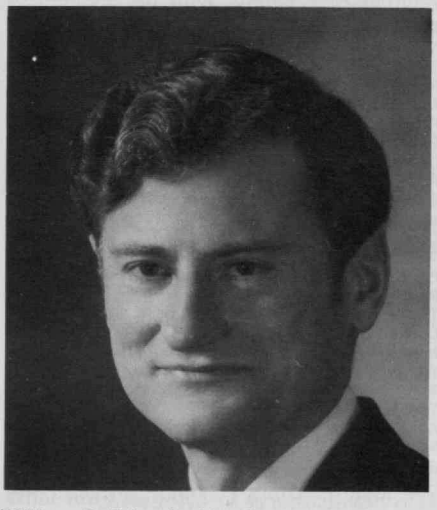
An Institute Professorship for An Engineering Education Innovator

Gordon S. Brown, '31, who "led a revolution in electrical engineering education in the 1950s" and then went on to lead an equally significant change in all of engineering education as Dean of M.I.T.'s School of Engineering in the 1960s, has been named Institute Professor.

Howard W. Johnson, Chairman of the Corporation, source of the above quote, told members of the M.I.T. Corporation and their guests on March 2, when the announcement was made, that an Institute Professorship is "the highest honor our faculty can pay to the few very distinguished colleagues whose career achievements and whose commitments to M.I.T. warrant exceptional recognition."

Dr. Brown will continue to hold the Dugald C. Jackson Professorship in Electrical Engineering as Institute Professor, and he will continue his present association with the interdisciplinary group at M.I.T. concerned with the development and application of urban dynamics.

As a student at M.I.T., Professor Brown was influenced by the work of Professors Vannevar Bush, '16, Harold L. Hazen, '24



William S. Edgerly, '49, first made his mark in the M.I.T. Alumni Association when he agreed to be regional Vice Chairman and later Chairman of M.I.T.'s Second Century Fund in Wayland, Mass., in 1958-59. By 1971 his many services to the Association, the M.I.T. Club of Boston, and the M.I.T. Corporation brought him the Bronze Beaver, highest award of the Association. Now he has reached the Association's highest office.

Beginning this summer, Henry A. Millon, Professor of the History of Architecture at M.I.T., will head the American Academy in Rome. Wishing him well, President Jerome B. Wiesner said "we rejoice in the true distinction of the post he will assume and take satisfaction that so prestigious a center for the arts and classical studies should have found new leadership at M.I.T."

A long series of honors was culminated for Gordon S. Brown, '31, on March 2 when he was named Institute Professor, the highest honor which members of the M.I.T. faculty can bestow on a colleague. He holds the two principal awards of the American Society for Engineering Education (Westinghouse and Lamme) and honorary degrees from Purdue, Dartmouth, Southern Methodist, Stevens, and the Technical University of Denmark.

and the late Norbert Wiener in the field of information processing, and his doctoral thesis (1938) was on an integraph machine which was a precursor of today's analog computers. Out of this experience Professor Brown came quickly to a vision of the future of computers and automation influenced by feedback controls, and he founded the M.I.T. Servomechanisms Laboratory in 1940.

Twelve years later, having risen through the ranks of the faculty to become Professor of Electrical Engineering, Dr. Brown relinquished management of the Servomechanisms Laboratory to become Head of the Department, a post which he held until his appointment as Dean of the School of Engineering in 1959. In both assignments he stressed the need for flexibility in education which would prepare students for rapid, unpredictable changes in technology.

Richards Awards: You Sent Outstanding Women to M.I.T.

Sixty-two high school principals, opening their mail from M.I.T. this spring, found a new kind of prize to add to the trophy cases: the Ellen Swallow Richards Honorary Awards from M.I.T. to recognize their high schools' outstanding women graduates who have come to the Institute over the years.

President Jerome B. Wiesner explained in an accompanying letter: "We wish to share our pride in our women with a few schools which also shared in their education."

Two other purposes were also in President Wiesner's mind: to commemorate the 100th anniversary of the graduation of Ellen Swallow, the Institute's first alumna, and to call attention of M.I.T.'s determination to increase the number of co-eds enrolled and to foster "a continuously expanding role for women in the professions."

Since Miss Swallow's graduation, more than 1,500 women have received degrees in virtually all the professional fields represented here. Today 700 women are enrolled, 300 as graduate students.

The schools receiving Ellen Swallow Richards Honorary Awards were:

West Anchorage High School, Anchorage, Alaska.
Beverly Hills High School, Beverly Hills, Calif.
Henry M. Gunn Senior High School,
Palo Alto, Calif.
East Catholic High School, Manchester, Conn.
The Norwich Free Academy, Norwich, Conn.
National Cathedral School, Washington, D.C.
The Sidwell Friends School, Washington, D.C.
Coral Gables Senior High School,
Coral Gables, Fla.
Boca Ciega High School, St. Petersburg, Fla.
McKinley High School, Honolulu, Hawaii.
Punahou School, Honolulu, Hawaii.
Kenwood High School, Chicago, Ill.
Bethesda-Chevy Chase High School, Bethesda, Md.
Winston Churchill High School, Potomac, Md.
Montgomery Blair High School, Silver Spring, Md.
Belmont High School, Belmont, Mass.
Girls' Latin School, Boston, Mass.
Archbishop Williams High School, Braintree, Mass.
Framingham North High School, Framingham,
Mass.
Haverhill High School, Haverhill, Mass.
Lexington High School, Lexington Mass.
Malden High School, Malden, Mass.
Natick High School, Natick, Mass.
Newton South High School, Newton Centre, Mass.
Newton High School, Newtonville, Mass.
Winchester High School, Winchester, Mass.
Ernest W. Seaholm High School, Birmingham,
Mich.

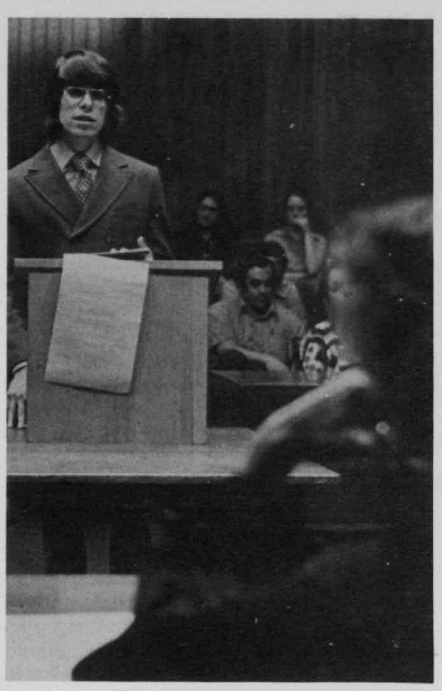
Wooden slats have been added behind windows in the passage connecting M.I.T.'s Dorrance and Dreyfus Buildings at the behest of Professor Harold E. Edgerton, Sc.D.'31, and grounds man Walter Crowe; they hope to reduce the number of birds—nearly 50 in two months—killed by crashing into glass-enclosed passageways on the East Campus. (Photo: Calvin Campbell)

Atlantic City High School, Atlantic City, N.J.
Hunterdon Central High School, Flemington, N.J.
Perth Amboy High School, Perth Amboy, N.J.
Princeton High School, Princeton, N.J.
East Meadow High School, East Meadow, N.Y.
Abraham Lincoln High School, Brooklyn, N.Y.
Erasmus Hall High School, Brooklyn, N.Y.
Midwood High School, Brooklyn, N.Y.
Forest Hills High School, Forest Hills, N.Y.
Great Neck North Senior High, Great Neck, N.Y.
Great Neck South Senior High, Great Neck, N.Y.
Mary Louis Academy, Jamaica, N.Y.
Mt. Vernon High School, Mt. Vernon, N.Y.
New Rochelle High School, New Rochelle, N.Y.
The Bronx High School of Science,
New York City.
Hunter College High School, New York City.
Rye High School, Rye, N.Y.
Edgemont High School, Scarsdale, N.Y.
Scarsdale High School, Scarsdale, N.Y.
Roy C. Ketcham Senior High School,
Wappingers Falls, N.Y.
White Plains High School, White Plains, N.Y.
Lincoln High School, Yonkers, N.Y.
The Baldwin School, Bryn Mawr, Penn.
Philadelphia High School for Girls, Philadelphia,
Penn.
Taylor Allderdice High School, Pittsburgh, Penn.
Lincoln School, Providence, R.I.
Mary C. Wheeler School, Providence, R.I.
White Station High School, Memphis, Tenn.
The Hockaday School, Dallas, Texas.
The Putney School, Putney, Vt.
Academia del Perpetuo Socorro, Miramar,
Puerto Rico.
Bishop Strachan High School, Toronto, Ontario.
Robert College of Istanbul, Istanbul, Turkey.
Ecole Internationale de Geneve, Geneva,
Switzerland.

The Toll of Birds at M.I.T. —and What To Do to Save Them

The toll of songbirds which kill themselves by trying to fly through glass-covered openings in homes and buildings is very large—but unknowable.

But Walter Crowe, who maintains lawns and gardens in the Eastman and McDer-



Half of the students in Professor William A. Davis, Jr.'s class in Urban Law were interested in going to law school, so Professor Davis thought they would welcome a chance to experience and test courtroom procedures. Hence a series of "moot court" sessions this spring; in this one Rory J. Albert, '74, speaks for a faculty aspirant who has been refused tenure at a private university.

mott Courts east of the main buildings, was troubled by the number of birds he found beneath M.I.T.'s windows. With help from Professor Harold E. Edgerton, Sc.D.'31, Mr. Crowe is turning himself into a qualified amateur ornithologist, and the two of them have become champions of such simple bird-warning methods as pictures on windows and curtains over glass walls.

In two months beginning on March 13, Mr. Crowe found 43 birds underneath windows of the Dreyfus (chemistry), Dorrance (life sciences), Whitaker (life sciences), Compton (electronics), and Hayden (library) Buildings: some 15 white-throated sparrows, five juncos, three brown creepers, and a number of far more exotic birds: woodcock, ruby-throated hummingbird, pheebe, ruby-crowned kinglet, flickers, cedar waxwing, sparrow hawk, black and white warbler, and others.

How to Keep Them Interested In Urban Law at M.I.T.

What are the rights of a woman who has been refused a tenured appointment at a private university, which has then appointed a male faculty member with approximately the same qualifications and background to the vacancy?

No such case has yet reached the U.S. Supreme Court; but it has been argued at M.I.T. by students in subject 11.12: Urban Law in a "moot court" session which duplicated the conditions of a court of law in every possible way.

The idea was that of William A. Davis, Jr.; he is Associate Professor of Urban Studies and Planning, and he surmised that, since perhaps a third of his class hoped to attend law schools after graduating from M.I.T., this format would provide a good chance to introduce urban and social problems "at a Constitutional level."

John A. Little, 1917-1973

John A. Little, who as Associate Comptroller of the Institute directed its budgeting, accounting, and financial reporting activities, died on May 2 at the M.I.T. Infirmary following a long illness. He was 56.

Mr. Little first came to M.I.T. in 1949 as an accounting officer; he had earlier served with Lybrand Ross Brothers and Montgomery and became a Certified Public Accountant in 1948. A graduate of Dartmouth College (A.B. 1939), Mr. Little had studied at Dartmouth's Amos Tuck School of Administration and Finance (M.C.S. 1940) before joining Lybrand's Boston office in 1940.

Mr. Little served from 1941 to 1945 with the U.S. Naval Reserve Supply Corps, attaining the rank of Lieutenant Commander.

Mr. Little was named Associate Comptroller of the Institute in 1961, with the Institute's accounting and payroll offices under his management. He was a member of the American Institute of Accountants, the National Association of Accountants, and the Massachusetts Society of Certified Public Accountants, and he was active in church and community affairs in Melrose, Mass.

Joseph C. Riley, 1877-1973

Joseph C. Riley, '98, Professor Emeritus of Heat Engineering in the Department of Mechanical Engineering, died on April 27 in Needham, Mass. He was 96.

Mr. Riley had continued at the Institute as a member of the teaching staff upon graduation (S.B. in mechanical engineering) from M.I.T.; he became a member of the faculty in 1908, rose to the rank of Professor by 1920, and retired as Professor Emeritus in 1942. His research and teaching had been in thermodynamics and other aspects of heat engineering.

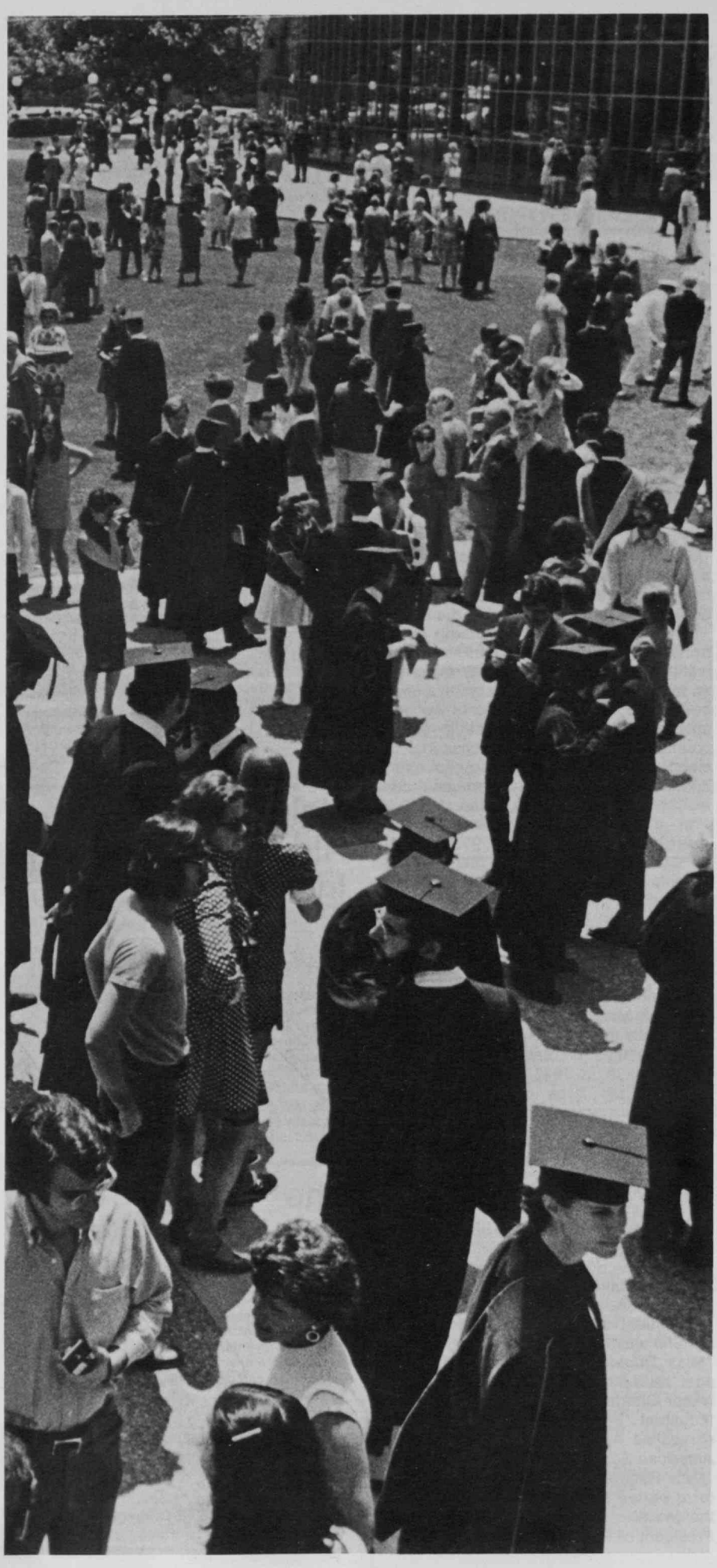
During World War I, on leave from M.I.T., Professor Riley served as a Major in the Air Service, assigned to the Technical Section of the Service of Supply.

Beatrice A. Rogers, 1899-1973

Beatrice A. Rogers, who was for many years a familiar figure to students in the Industrial Relations Section of the M.I.T. Department of Economics, died on May 22. She was 74.

Miss Rogers retired in 1969 from her post as Administrative Assistant to Professor Charles A. Myers, who headed the Industrial Relations Section; she also served as Assistant to the Editor of the *American Economic Review*.

Miss Rogers first came to M.I.T in 1941; for a period she interrupted her career at the Institute to work as Secretary to the President of Radcliffe College.



1,300 Students, 1,400 Diplomas at the Ceremony for Mom and Dad

The proceedings were simple, almost completely without surprises. Nearly 1,300 students received about 1,400 diplomas before an audience of about 4,500 on Friday, June 1, in the 107th annual culmination of academic careers—M.I.T.'s 1973 Graduation Exercises.

At 9 a.m. on the stage in Rockwell Cage, a workman was still insinuating a vacuum cleaner between the lectern bearing the M.I.T. seal and a stand on which rested diplomas in red vinyl covers. At two doors at the rear of the Cage, guests were already waiting to be admitted. (The Cage itself somehow manages two ambiences simultaneously, those of an airplane hangar and of a Medieval jousting arena. All windows are curtained, those behind the stage in orange, those around the remainder of the perimeter in yellow-white. The floor is of packed dirt. Nets that catch stray basketballs are today hoisted and tied away like reefed sails.)

At about 9:10, members of the brass choir began arriving; one early musician began to tune his tympani. At about 9:15, ushers began letting in guests.

Inside the "Robing Area"

9:30. The graduates are assembling in the "robing area"—du Pont Gymnasium, adjacent to the cage. Virtually all seem to be cheerfully enduring the ceremony for Mom and Dad. At 10 a.m., while the Cage is filling up, the graduates are receiving their instructions. In du Pont, 30 lines will form at 30 "stations," each labelled by course and level of academic degree. In a half-hour, the lines will be merged in succession into an academic procession that will file four abreast into the Cage. A first check of name order will be made in ten minutes, when ushers at each station will compare the order of their lines with their lists. The second check will occur just as the procession enters the Cage; each graduate will give his name to a checker, who will thus perform the second confirmation that the sequence is correct. A third check will occur as the graduates rise, row by row, to receive their degress. The procedure will insure that, without need of rehearsal, each graduate will actually receive his or her diploma from the Institute's President—an achievement apparently not matched today by most schools. In item five of an instruction sheet, degree candidates are warned in underlined type not to shake President Jerome B. Wiesner's hand; Dr. Wiesner would have to endure, after all, 1,200 shakes. Upon the announcement that the graduates will be the first in the academic procession and the last in the academic recession at the end of the ceremonies, there are a few laughs and hisses. The Marshal of Graduates agrees: "Though this may seem like an honor," he tells them, "in effect it means you do the most waiting."

At 10:30 the academic procession begins, a black-gowned line threading its way from right-rear of the Cage to the center aisle. It is almost late; members of the M.I.T. Corporation were delayed by a long agenda at their breakfast meeting,

and only when they are in their special robing area ("Guests of Honor") can the procession be started. At the front of the guests' seats, the four component files of the procession divide, the center two continuing into the seating for the graduates, the leftmost and rightmost files dividing to either side of their seating area. The graduates remain standing upon arriving at their seats.

The academic procession continues with the Chief Marshal, Breene M. Kerr, '51, President of the Alumni Association, arrayed in "a distinctive cap and gown designed for the M.I.T. Commencement" (to quote *Graduation Exercises 1973),* all cardinal red, including a curious headgear somewhat like a fallen souffle. The Chief Marshal carries the M.I.T. mace.

Members of the 50-year class and of the M.I.T. Corporation, representatives of the faculty, the guests of honor (the Deans, the Registrar, and Dr. Paul M. Fye, President and Director of the Woods Hole Oceanographic Institution), and the principals followed the Chief Marshal, who remained at the base of the stage until the others had assumed their seats, faculty members at the extreme left and right, the Class of 1923 at the left-center, and the Corporation at the right-center. Finally, the Chief Marshal hoisted the mace on his shoulder and ascended. Howard W. Johnson, Chairman of the M.I.T. Corporation, advanced to the lectern to announce that the graduation exercises were hereby convened.

M.I.T. does not award honorary degrees, nor does it hear any speeches at graduation exercises other than the one delivered by its President.

Pride, Relief, and Applause

"Mrs. Wiesner and I have sat where you are sitting," Dr. Wiesner began, "and I believe I have a sense of the tremendous pride [he paused] and relief you all must feel on this happy day . . ." After asking that the graduates and faculty rise and applaud the families of graduates, Dr. Wiesner resumed by indicating what he would not be speaking about: "It would hardly be constructive, though I found it tempting, to talk about Watergate." (Dr. Wiesner mispronounced it "Washergate," then chuckled.) He continued: ". . . At a moment when our democratic institutions are under severe strains and are being tested, it is appropriate for me to at least wonder if any other message will be heard." But he proceeded on the optimistic assumption.

"I almost believe," he said, "that effec-

(Continued on p. 106)

Some of its participants describe M.I.T.'s Graduation Exercises as a ceremony to be "cheerfully endured . . . for Mom and Dad." President Wiesner, opening the ceremonies, expressed the same sentiment when he asked the graduates and faculty to rise in honor of the parents present. Yet the graduates' emotions were not lost on Dr. Wiesner: "I believe I have a sense of the tremendous pride and relief you all must feel on this happy day . . ." (Photos: Calvin Campbell)

Focus on Both Journey, and Objective

Following is a digest of the address by President Jerome B. Wiesner to members of the Class of 1973 at the Institute's 107th Commencement Exercises on June 1.

It has become the fashion to attribute most of our ills and unhappiness to the impact of science and technology, and I know that this troubles many of you, as it does me. I am convinced that this is a superficial and almost wrong analysis of the situation. As I become more familiar with the realities of the problems of our times, I am convinced that focusing on science and technology as the villain masks a more fundamental difficulty—namely, how to induce an adequate corrective response to any problem we must solve together.

Effective means do not exist for achieving societal goals. This is in large measure because we are oblivious to the importance of understanding the processes through which we pursue collective goals. Consequently, they often cannot be fulfilled, at least on the selected timetable, with the resources usually allocated to them and in the legal and social context that exists. We repeatedly put ourselves into impossible situations in this way; and when we fail to achieve the unrealistic objectives, we react with bitterness.

Norman Zinberg has suggested that our society has become so goal-oriented that we ignore the vital aspect of process. This seems to me true at all levels. For the individual, the process that he is part of day after day can be fulfilling or frustrating, enriching or debasing; and although it is clearly a vital matter—it is his life and in the end it forms his life—rarely is this process a prime consideration, even in a university. It seems to me that our society is suffering in a similar way: there are too many encounters with frustrating processes.

But there are signs of change. We are beginning to focus on the journey as well as the objective. This is the lesson young people have been trying to teach us. Workers shun some jobs and students shun some forms of education. Both are trying to make their environments more nearly meet their expectations. *How* something is accomplished may be as significant or possibly even more important to the participant than *what* is done. Industry and universities are trying to understand and respond.

Technical Goals and Human Goals

It is very common to hear a person frustrated by one of our major societal problems say, "If we can put a man on the moon, why can't we" . . . teach every child to read . . . or whatever his own chief concern happens to be. The implication is that any large task has a solution and is merely a technical challenge. In most situations, the overlooked human elements completely overshadow any technical component, and one aspect interacts with many others. The clearly desirable efforts to control environmental pollution, for example, have certainly helped bring on the energy crisis and have had many other substantial and costly consequences that were not anticipated.

When a technical goal is proposed, well-established techniques are used—as you know—for studying its feasibility. Design and management methods—processes—are at the same time available for achieving it if it appears desirable. Poetically speaking, the moon stands still—and it certainly does for purposes of research and exploration. Social goals are not standing targets. Here the uncertainty principle works with a vengeance. In setting out to meet social needs, whether or not they involve technology, we have failed to face the changing, complex and little-understood nature of the processes which would have to be employed. In fact, one rarely even inquires as to whether the restraints imposed by the social setting or the resources available allow the goals to be achieved at all.

Inevitably, many of the most ambitious and desirable social goals prove more elusive and more costly and time-consuming than predicted, so that—in spite of genuine progress—impatience, disillusionment, and alienation occur and cause the programs to be drastically modified or abandoned.

Toward More Effective Human Change

The federal government is phasing out a vast collection of education, health, urban, and research programs that its leaders judge to be inadequate or obsolete and which will leave a vacuum that will clearly need to be filled, since the problems are still there. Now is a good moment to look at processes that seem to be wanting and goals that are overly ambitious with a broader vision of the complexities and with concern for the human beings involved, in order to create programs that are more effective and less divisive. We should, as some sophisticates would say, recognize that they, our social systems, are complex ones, and we should expect to manage them with the same thoroughness that we would employ on a purely technical problem.

Many of you are bound to become involved in some aspect of social improvement—perhaps technical in nature, perhaps not—whether you choose careers in industry, university, or government. You will have perhaps recognized the difficulties of change even in the setting of M.I.T. If we appreciate that much of the difficulty encountered in raising social standards during the last three decades has come from an understandable preoccupation with goals, we can then, with greater humility, have the courage to rededicate ourselves to these worthwhile goals, armed with more appropriate methods for their achievement. Developing these methods is a task worthy of our best efforts.

Commencement is a time for . . .
. . . housecleaning—the skylight in the Rogers Building lobby was washed for the first time in what The Tech *called "a number of years" in preparation.*
. . . reunions—mother and son at the "graduation eve" party in the Student Center.
. . . reminiscing—members of the 50-year class gather for their tribute as guests of honor.
. . . pleasantries: Howard W. Johnson, Chairman of the Corporation, observes the mace by which Professor Hartley Rogers, Jr., enforces his role as Marshal of the Faculty.
. . . and sightseeing (above) in the Great Court. (Photos: Roger Goldstein, '74, Sheldon Lowenthal, '74, and Susan Pogany)

Man and Nature as a Single System

The following is the address by Julius A. Stratton, '23, President Emeritus of M.I.T., to members of the Class of 1973 at the Commencement Luncheon on June 1.

In the vast perspective of history 50 years is a very short time indeed. But the extent and acceleration of change in those years—affecting every nation and every one of our institutions—has no parallel in the history of mankind.

True, from time immemorial there has been change. There have been revolutions and evolutions, plagues, riots, disruptions, and reformations. But the social and material change that envelops us today is a movement of quite another magnitude—a swelling tide that is sweeping us along into a new world unlike anything that man has seen before. The driving force of that tide, as we well know, derives from prodigious advances in science and technology, from powers that we have gained to alter and master our environment.

We hear much these days about the potential consequences of exponential growth. No one can deny its reality—not alone in population, but in the dimension and complexities of problems arising from the progress of modern culture. Today I believe we find ourselves on the threshold of a new era, calling for a new concept of progress, and a new level of judgment and understanding.

Isolated Targets and Single Solutions

The great technological triumphs of our lifetime have been achieved largely by virtue of a single-minded, unswerving pursuit of a specific goal. In the simpler world in which we have lived, it was possible to isolate our target and drive towards it without regard for other consequences that then seemed to be wholly secondary to our purpose.

We needed power, and so we designed and built the necessary turbines and generators and transmission lines. We wanted transportation, and so we paved thousands of miles of highways and produced millions of motor cars. A multitude of industrial plants throughout the land have contributed to making this the wealthiest nation in the world as well as providing the highest level of material comfort that man has ever known. These are tremendous accomplishments, and no one of us would wish lightly to put them aside.

But now the scene is changing. A new factor enters the picture—a factor that I call the density of development. No longer are we free to plan and build in a rarefied state. No longer can we pursue a single enterprise without regard to its interaction or possible collision with others. As but a single example—suddenly we have awakened to the problems of pollution, to grave damage to our environment, to the rapid depletion of our natural resources.

And too often the reaction to this new array of concerns has itself been narrow and limited in perspective. Our environment is a precious heritage which we must protect and preserve. But to launch forth on a program to restore the wild kingdom that takes no account of many other dimensions of the problem—both social and economic—may only deepen our distress.

To Learn the Whole, Study Its Parts

In words which this audience will well understand, I am saying simply that the time has come when we must recognize that man and nature constitute a single dynamic system. And if we are to understand that system and develop it for our continuing benefit, we must probe deeper into the coupling and interplay of the manifold forces—technical, economic, environmental, social, political—that in the final reckoning combine to determine the behavior of the whole.

This is not a perfect world; it never has been, never will be. But never has such a store of knowledge and power been entrusted to man. Our hope for the future lies not in the rejection of science and technology, but rather in their intelligent and constructive use.

Yet for all our faith in the mission of science, we must guard against relegating to science the responsibility for moral decisions that man alone must make; and we must beware also lest we discard basic moral principles in the expectation that science will take care of the consequences. The remedy for our present ills—such as they are—lies in a clearer understanding of the meaning and potential consequences of what we do and an awakened moral and aesthetic sensitivity in deciding where we go. We must seek an ever deeper insight into the system of man and nature; we must plan ahead with a balance of judgment and foresight; and we must act wisely and responsibly.

Opportunities Without Limit

On that June day in 1923, our Commencement speaker concluded his remarks with these words:

"You are to be congratulated upon the fact that you are starting your active careers in the most interesting and stirring period of the world's history. I realize," he said, "that we are only at the beginning of the new era which science and technological knowledge are creating, and I can scarcely avoid a feeling of envy for the limitless opportunities which lie before the generation to which you belong."

Today I believe that I can truly say to our new graduates that exciting opportunities are still there—indeed, without limit. I, for one, cannot subscribe to the mood of pessimism that has become so common of late in so much of the Western world. True, the problems of contemporary society are legion in number. There are visible perils. But there are above all tantalizing possibilities to challenge your imagination, your energy, and your will. I have no doubt that you will respond. We of the Class of 1923 will be looking forward with eagerness to your report in 2023.

While Maria Bozzuto, '73, should have been receiving her diploma from M.I.T., she and four other M.I.T. coeds were at Fort Schuyler, N.Y., winning for the Institute the Women's National Intercollegiate Sailing Championship at the State University of New York. But the race was not sailed in academic regalia: this was made as a "gag" picture by the M.I.T. News Office before Maria left for the meet.

(Continued from p. 103)
tive means do not exist to satisfy societal goals," but this is so only because, in our preoccupation with goals, we have neglected *processes.* The result is that "we repeatedly put ourselves into impossible situations . . . and when we fail to achieve the unrealistic objectives, we react with bitterness." Yet "there are signs of change. We are beginning to focus on the journey as well as the objective. This is the lesson young people have been trying to teach us. . . . *How* something is accomplished may be as significant or possibly even more important to the participant than *what* is done. Industry and universities are trying to understand and respond."

"Poetically speaking, the moon stands still"—a target for technology. But "social goals are not standing targets," Dr. Wiesner said, and "here the uncertainty principle works with a vengeance.

"Now is a good moment to look at processes that seem to be wanting and goals that are overly ambitious with a broader vision of the complexities and with concern for the human beings involved, in order to create programs that are more effective and less divisive. . . . If we appreciate that much of the difficulty encountered in raising social standards during the last three decades has come from an understandable preoccupation with goals, we can then, with greater humility, have the courage to rededicate ourselves to these worthwhile goals, armed with more appropriate methods for their achievement."

An explosion from a Chinese gong began a performance of Aaron Copland's *Fanfare for the Common Man* by the brass choir. Following it, the graduates filed to the stage, where, after hearing their names announced by the deans of their schools, they received their degrees. All appeared to go well: 840 bachelor's degrees, 392 master of science degrees, 18 master of architecture degrees, 16 master of architecture in advanced studies degrees, 21 master in city planning degrees, 74 engineer degrees, 23 doctor of science degrees, and 103 doctor of philosophy degrees went from Dr. Wiesner's hands to those of their rightful owners at the ceremonies. Of the total of 1,290 graduates, 99 were women: 57 undergraduates and 42 graduate students.

Guests moved toward the doors as the last of the academic recession left the Cage. For perhaps an hour after the conclusion of the ceremonies at 12:50, parents could be found about the campus, positioning their robed children, their spouses, and other smiling persons against one or another of the campus' buildings, then backing off a few feet and fumbling with cameras.

The Oath of Military Service: One Constant in a Changing World

When the cadets and their proud parents assembled on the morning of May 31 for the first event of M.I.T.'s Commencement, only 16 R.O.T.C. commissions were awaiting their recipients. For this was the class which entered the Institute in September, 1969, when Michael A. Albert, '70, President of the Undergraduate Association, was calling M.I.T. "the second Pentagon" and promising "to raise the price of war until its masters end it."

There is still a generation gap, said Rear Admiral Richard E. Rumble, Commandant of the First Naval District, speaking at the Commissioning Exercises. "It is your generation that we have educated more thoroughly, granted more liberties, more freedom, more exposure to the ways of life," he told the cadets.

"It is also your generation who is questioning the preachings, the teachings, the traditions . . . of your predecessors."

All this he applauds, said Admiral Rumble, guessing that out of it will come a generation "with stronger moral values and a better society."

But one value is a constant, warned Admiral Rumble: "The acceptance of an oath or swearing to a promise should be as important in this new society as it has been in the old. . . . With an oath goes a responsibility—an obligation to meeting a commitment."

After the ceremony at which he presided, President Jerome B. Wiesner told *Technology Review* that though he had mixed feelings about the existence of a military establishment (necessary in an unstable world, he admitted)—he regretted that the R.O.T.C. class in 1973 was so small and that so many New England colleges and universities had entirely dropped the program. The result is that New England is little represented (and the Southern states overrepresented) in the armed forces—a situation not ideal for national organizations so powerful as this one, thinks Dr. Wiesner.

Dick Gregory to the Class of 1973: Find Out "Who You Are and What You Are About"

He may be called a "comedian," but Dick Gregory's Class Day address to M.I.T.'s 1973 graduates had in it the steel blade of political sarcasm as well as the glitter of good spirits.

No summary will record the brilliant 90 minutes in Kresge Auditorium on May 31. A series of quotations—one reporter's view of the highlights of a rambling, expert, and fascinating performance—will have to suffice:

"President Nixon's luck is so bad he cannot even oppose busing any more. Because of the gasoline shortage there won't be any buses."

"What would happen to Jesus if he came back to America today—his long hair, his beard, his robes, his bare feet . . . if he walked into a church and said, 'You can stop speaking for me; I'll speak for myself' . . . if he walked into a hospital—they'd call the police!"

"I guess I could truthfully say I spend 90 per cent of my time today on college campuses. That's because you young people are the most morally honest and dedicated generation ever. But I hope you understand—it's very important — that no institution in this country can prepare you for understanding who you are and what you are about." "Someone's got to turn us around; every American President went to college—doesn't that scare you?"

"The system tells me that I shouldn't have too many kids—because of ecology and all that. But the same system would sell me 5,000 Cadillacs if I had money to pay for them."

"There's no population explosion in America—just a stupidity explosion: 98 per cent of Americans live on 2 per cent of the land, and that's what the problem is."

"One person with courage can always be the positive majority."

"President Nixon talked about law and order. But if you vote for law and order

without asking where justice is, then you're on the way to Nazism."

"Consider this universal law: when you, belonging to one race, cause animosity in another race, then you are only hurting yourself. Think about President Nixon: his fate is controlled by the blacks on the Watergate grand jury; it's black because all the white people have moved out of Washington, into the country. The Watergate people were discovered by a black who became a security guard when he lost his other job because President Nixon cut back poverty funds."

"My mother told me, 'I'm the government. Can I make you go to bed when I'm ready? Yes. Can you make me go to bed when you're ready? No. Then I'm the government!' "

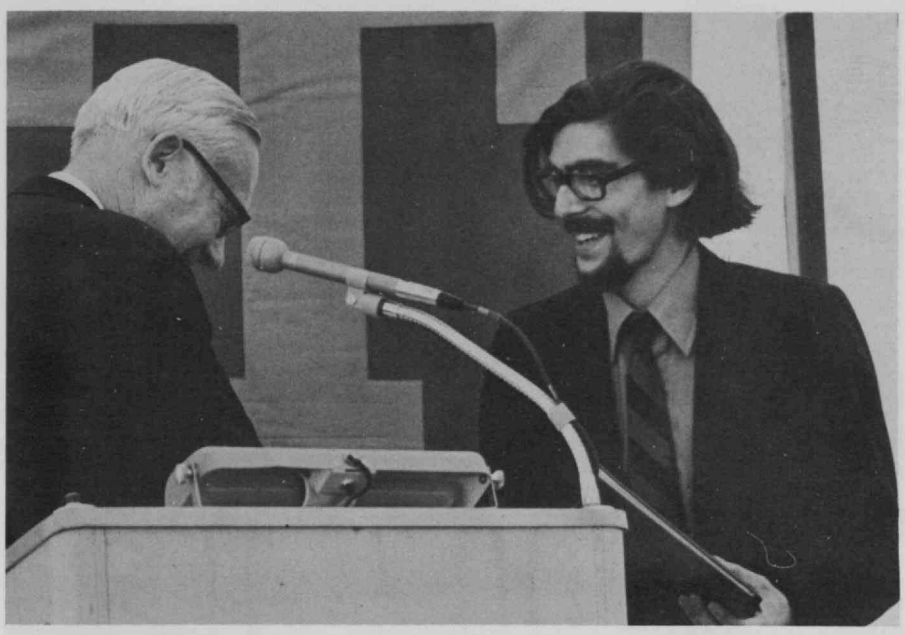
"Morality in this country has nothing to do with what you do but how you look when you get through doing it."

Coming to Grips with a Different World? "I Don't Know How!"

How different is today's world from yesterday's depends on who you ask.

Julius A. Stratton, '23, President Emeritus of M.I.T. who spoke for his 50-year class at the Commencement Luncheon on June 1 (*see p. 105*), thinks the world of today is very different indeed. "The social and material change that envelops us today is . . . a swelling tide that is sweeping us along into a new world unlike anything that man has seen before. . . . Today I believe we find ourselves on the threshold of a new era, calling for a new concept of progress and a new level of judgment and understanding."

"I spend 98 per cent of my time on college campuses because I believe today's students are the most moral in the history of the country," said commentator/humorist Dick Gregory at Class Day at M.I.T. on May 31. The black graduating seniors of the Institute returned the compliment with a citation to Mr. Gregory for his "efforts in bringing the message of brotherhood and peace to the world." (Photo: Sheldon Lowenthal, '74)



When Irwin W. Sizer (left), Dean of the Graduate School, finished reading the testimonials for Alan J. Grodzinsky, '71, for the Goodwin Medal for effective teaching, President Jerome B. Wiesner wondered that any student was "willing to take that much embarrassment for $500." Mr. Grodzinsky's award honors the late Harry Manley Goodwin, '90, the first Dean of the M.I.T. Graduate School.

Robert J. Longair, President of the Class of 1973, is not so sure. Responding to Dr. Stratton, Mr. Longair described how he had spent the night before Commencement (as he supposes the 50-year class did in 1923) "thinking over" the past four years. Was it really so different 50 years ago? Mr. Longair thinks perhaps not—"the same achievements, disappointments, . . . the same problems we encounter today."

But in one respect today's graduates are different from those of 50 years ago: "Our friends and colleagues are no longer defined by the borders of a city, state, or nation," he said. "We are responsible now to the courts of the world; our actions influence the people of the world." His hope for the future is that we "can as easily then justify sending food, shelter, and learning to other nations as we now justify sending guns and tanks."

"I hope my classmates and I can come to grips with the fact that we can no longer build walls to keep out the problems of the world," said Mr. Longair. "And I don't know how to do it," he said.

"A Great Guy and a Fantastic Teacher"

"A superstar who deserves the recognition of the Goodwin Medal"—a faculty member's words of recommendation—were honored on June 1 when Alan J. Grodzinsky, '71, did in fact receive M.I.T.'s highest award for a graduate student "for conspicuously effective teaching." He is an instructor in the Department of Electrical Engineering.

The competition for the Goodwin Medal is intense, but Mr. Grodzinsky's recommendations, as recorded by Irwin W. Sizer, Dean of the Graduate School, at the Commencement Luncheon before he gave Mr. Grodzinsky his medal and $500 honorarium, are beyond reproach. "A continuous train of students passing through his office," wrote one faculty member. "Demonstrable positive effect on students," wrote another. "One can only hope to encounter a few in a lifetime, even at M.I.T."

Students participated in the nomination, too. "A great guy and a fantastic teacher," wrote one. Another: "The best teaching assistant I've ever had—better than most of the professors I've had." "His presentation of Fields, Forces, and Motion was one of the most refreshing classroom experiences I've had at M.I.T."

If these testimonials weren't enough, Mr. Grodzinsky's nomination for the Goodwin Medal was substantiated by a computer-aided student evaluation of the electrical engineering teaching staff this spring.

Mr. Grodzinsky came to M.I.T. from Levittown, N.Y. to receive both S.B. and S.M. degrees in electrical engineering; he will complete doctoral studies in 1974. A member of the M.I.T. Symphony Orchestra (viola), Mr. Grodzinsky also plays in a string quartet with the intriguing name of "No Dogs Allowed."

Tang Residence Hall: "An Extremely Calming Effect"

Though he is "usually called upon by the residents to say other things than thanks," on June 1 there was no doubt: "It's not luxurious, and it's no bargain. But it's convenient, and it beats anything I've seen in Cambridge.

"And when you're wondering how you will manage to live in Cambridge a letter saying you can live in Tang Hall has an extremely calming effect."

These words of understated praise came from Robert E. Sacks, a graduate student in mathematics who was elected by the residents last fall to represent them as Administering Officer of Westgate II, the Institute's new apartment residence for single graduate students at the west end of the campus.

Mrs. Ping Yuan Tang (center) let her son, Jack C. Tang, '49, speak for her at the dedication of the Tang Residence Hall at M.I.T. on June 1; he referred to the family's "overflowing pride and grateful appreciation for this magnificent tribute to my father." With Mrs. Tang are Howard W. Johnson (left), Chairman of the Corporation, and President Jerome B. Wiesner. (Photo: Susan Pogany)

After the dedication ceremony on June 1, the building has become the Tang Residence Hall, named for the late Ping Yuan Tang ('23), whose gift (the exact sum was not announced) was the largest private contribution to the fund which made possible the building. It was also the largest contribution ever received by M.I.T. from outside the U.S.

President Jerome B. Wiesner's praise for the Tang Residence Hall was unreserved. He admitted that the "maiden voyage" was "somewhat stormy"—a reference to construction delays which plagued the building many months after the residents moved in. But now, said Dr. Wiesner—probably thinking of the view of M.I.T. and Boston from the 24th floor and the half-mile traffic-free walk from home to office—those who live there are "the envy of us all."

Speaking for the family at the dedication, Jack C. Tang, '49, recalled his father's "fierce pride" in M.I.T. The Institute, he said, is seen in Hong Kong as "a towering symbol of international quality in scientific education. The fame of M.I.T.'s engineering school became part of my dreams," said Mr. Tang, and "there was no question about what school I would go to."

The same thing happened to a third generation of the Tang family, too—Martin Y. Tang, Ping Yuan Tang's grandson, received the S.M. in management in 1972.

The commitment for the gift was made by Mr. Tang before his death, and it was later honored by the family; "nothing we could have done would have pleased my father more," Jack Tang said at the dedication.

Howard W. Johnson, Chairman of the Corporation, in his turn saluted the Tang family "for their cosmopolitan example." After graduating from M.I.T. in management, Mr. Tang returned to Shanghai to found a major industrial complex in the manufacture of textiles, flour, and cement. When the communists took power in China Mr. Tang moved to Hong Kong, where he rebuilt his enterprises through the South Sea Textile Manufacturing Co., Ltd.

Throughout his life, said Mr. Johnson, Ping Yuan Tang "placed great importance on education." He arranged for his firm to provide free schooling and vocational training for its 2,500 employees, founded the Community Chest of Hong Kong, was Chairman of the Board of Governors of New Asia College and a member of the Board of the Chinese University of Hong Kong, and at the time of his death was leading a committee of Hong Kong leaders planning for a polytechnical institute in that city.

Tang Residence Hall was designed by Hugh Stubbins and Associates of Cambridge and built by Jackson Construction, Co., Needham. Public funding through the Massachusetts Health and Education Facilities Authority and the U.S. College Housing Loan Program was supplemented by private funds—including Mr. Tang's gift and a matching grant from the Kresge Foundation.

Richards Professorship for Alumnae: A New Honor for M.I.T.'s First Alumna

Ellen Swallow Richards, who graduated in chemistry in 1873 as the first woman to hold an M.I.T. degree, might not have been surprised at all; for the record shows that she was conscious of her role as a pathfinder for her sex and that she continued to press the Institute—and her country—on the issue of women's rights throughout her life.

Now that determination has been commemorated by the Ellen Swallow Richards Professorship at M.I.T.

Opening the convocation of the Association of M.I.T. Alumnae on June 2 (*see pp. 110-111*), President Jerome B. Wiesner announced the new endowment and reported that between half and two-thirds of the money needed to fund it has been received.

When the fund is complete, he said, the Professorship—intended to be occupied "primarily by our own M.I.T. alumnae"—will "recognize the national importance of contributions by women to research and education at M.I.T." The Swallow Professorship will be reserved "for distinguished women members of the faculty," and it will be available for appointments in all of the Institute's five schools.

And Dr. Wiesner also pledged his administration's continuing efforts, in other ways as well, "to increase the participation of women" in all aspects of M.I.T.'s affairs.

Alumni Day: Pops, Strobes, and New Roles for Technology

James O. McDonough, '43, and the members of his 1973 Alumni Day Committee took no chances—Salvatore Lauricella, Arthur Fiedler, Harold E. Edgerton, Sc.D.'31, President Jerome B. Wiesner, J. Herbert Hollomon, '40, Margaret L. A. MacVicar, '64, and Dr. Salvador E. Luria—star performers every one.

Salvatore Lauricella is Manager of the Student Center Food Service. In five days of Commencement, alumni reunions, women's convocation, and Alumni Days, from May 31 through June 4, some 5,972 special meals—and uncounted drinks and hors d'oeurvres—were served from his kitchen.

Arthur Fiedler needs no introduction to any M.I.T. Alumni Days audience, and the affection which they hold for him is apparently reciprocated: Mr. Fiedler appeared on stage Sunday night wearing the red coat of the M.I.T. Class of 1922.

No introduction needed for "Doc" Edgerton, Institute Professor Emeritus, either. He opened the Monday Alumni Day program by initiating over 750 alumni and their guests into the ranks of fully-accredited stroboscopists.

"Doc's" anecdotal review of the history of high-speed photography included pictures of bullets passing through oranges ("We only did this once—the orange juice, you know . . ."), movies of bats catching mealworms made by infrared strobe lights (Where did he and David A. Cahlander, '59, get their bats? By "the sockful from Harvard."), the Smith College water ballet (demonstrating "what 'simultaneous' means to a Smith College girl"), and others.

Highlights of the Alumni Day Luncheon are reported elsewhere *(see below)*—except these: of 800 alumni and guests, the oldest was Arthur L. Collier, '02, of Marblehead, one of the youngest Bradley Kerr of Tulsa, Okla., the son of Alumni Association President Breene M. Kerr, '51.

The most serious intellectual fare of Alumni Days was reserved for Monday afternoon, when Walter A. Rosenblith, Provost, presented three of the Institute's most respected—and lively—faculty:

Technology Among Our Values

Like a fish in a fishbowl who cannot see the water in which he swims, we have great trouble when we search for an objective view of our world, thinks Dr. Hollomon, who directs the Center for Policy Alternatives in the School of Engineering. Having made such a search, Dr. Hollomon proposed three basic changes in the U.S. since World War II:

☐ The position of this nation with respect to the rest of the world is now very different. Per capita wealth of other countries is increasing more rapidly than ours, we find "severe competition" for the products of our technology on the basis of both price and value, our share of world trade is declining and our balance of payments growing ever less favorable.

☐ "The largest immigration in the his-

(Continued on p. 112)

How to make a university president happy? Follow the example of the Class of 1923: give him $17.5 million. That's David W. Skinner, '23, Reunion Gift Chairman (top), handing President Jerome B. Wiesner the record-breaking gift during the Alumni Day luncheon. (Photo: Sheldon Lowenthal, '73)

How to make the old grads happy? Follow the example of Salvatore Lauricella, Manager of the Student Center Food Service: give them plenty to eat. That's the international buffet (bottom) which officially opened the 1973 Alumni Days on Sunday evening, June 3. (Photo: Sheldon Lowenthal, '73)

Focus on the Future: A Convocation Celebrating Women

To celebrate the centennial of the first woman's graduation from M.I.T., the Association of M.I.T. Alumnae asked the Institute to focus on the future—not necessarily of women (some people expected that) but of the nation and its society as a whole . . .

. . . an ambitious prospectus for a two-day convocation, and the promise of the title could hardly be fulfilled Better to record simply some highlights, a summary of what seemed of greatest interest in 14 hours of speeches, panels, and seminars.

The Middle East: "Our Very Jugular"

Five strands leading into the future seem important to Admiral Elmo R. Zumwalt, Chief of Naval Operations who is known as a champion of women and minorities in the U.S. Navy:

☐ There has been remarkable progress in arms control; having achieved "the first successful limitation of defensive arms," can we now move on to limitations on offensive weapons? Admiral Zumwalt finds himself not sure. Since S.A.L.T. I brought the two great powers to a stage of approximate equality, the Soviets "have done everything permitted by the treaty—a very successful job of improving the quality of their defensive systems." In view of this, Admiral Zumwalt thinks it "very important that the U.S. continue our own qualitative improvement" of advanced weapons systems.

☐ Man's "best hope for survival is more effective and intelligent use of the seas."

Energy is one of the nation's most critical issues. Even as we press ahead with research and development on new energy sources we become increasingly dependent on imported petroleum from the Middle East—where the Russians are aggressively strengthening a presence that "can raise the prices of our oil and harm our economy in the years ahead." Indeed, Admiral Zumwalt thinks the Middle East is "our very jugular," and he wants the U.S. to move as quickly as possible to free its reserves of oil in Alaska and in its territorial waters.

Can Men and Women Truly Share?

Androgynous a new word to you?

It means shared roles for men and women, and it is the way of the future, thinks Mary P. Rowe, Special Assistant to the President and Chancellor for Women and Work at M.I.T.

For example, Dr. Rowe described a shared academic appointment—husband and wife each working about three-quarters time and each sharing homemaking and child care.

"Suppose we assumed that both men and women were completely free to share financial responsibility, child custody, child care, homemaking. I believe that we would see . . . many more three-quarter-time workers, especially among young parents."

Some of the advantages: "Family finance would be more secure. There would be more jobs to go around in times of unemployment. Both men and women would have more variety in their work lives. Both would have at least one area of work—at home—with considerable autonomy. Both would have two areas of work in which to acquire skills and self-esteem and a feeling of identity and purpose. Husband and wife would share a common purpose as on the old-time farm. . . ."

But this vision, if even achievable, is far from today's reality. "I believe that our understanding of maleness and femaleness and of the relations between the sexes is among the most primitive, potentially painful areas we can consider," said Dr. Rowe. "Power, status, money, security are at stake as we reorganize toward androgyny. . . . But I believe that both men and women are finding that they have much to gain. . . . Wider opportunities to love and to work mean more variety, more interest, more companionship, more joy in the 24 hours of the day."

"The Artistic Setting of Our Lives"

Can a technological future include art?

It can indeed, thinks Gyorgy Kepes, Institute Professor Emeritus who is Director of the Center for Advanced Visual Studies; and it must. The key is to focus our attention on ways of expressing ourselves, eschewing "packaged expressions." For example, instead of buying a birthday cake, design one yourself. Have the courage to "accent the peak moments of your life" by creating "focal points of inner happiness."

The problem is "to move art from being irrelevant to fundamental," to concentrate far more attention than in the past on "the artistic setting of our lives."

Women's Places in America? At the Helm of the Washington Post, Among Others

Though she made no direct references to the subject, Katharine Graham, President of the Washington Post Co., by her poise, eloquence, and power may have said as much about woman's place in the highest echelons of American society as any speaker with flaming oratory on women's liberation.

Introducing Mrs. Graham, Howard W. Johnson, Chairman of the Corporation, said she would describe "a service in the cause of the republic seldom equalled by the public press." And so she did, in a brilliant address on what she called "some lessons from the whole sleazy business" of Watergate—"a new form of corruption in government which is unprecedented in involving so many men so close to the President."

As Florence Luscomb, '09, told it, M.I.T was more than a little uneasy when Ellen Swallow ('73) applied to study at "Boston Tech" in 1870. (Miss Luscomb, who traced the early history of women at M.I.T., guessed she might be the only person at the convocation celebrating the centennial of Miss Swallow's graduation who had actually known Miss Swallow personally.) Granting her admission to the Institute, President John D. Runkle wrote the new coed that "you shall have any and all advantages which the Institute has to offer without charge of any kind." Ellen Swallow thought this a remarkably generous arrangement—until she later learned that "it was because he could say that I was not a student if anyone should raise a fuss." No one did, and coeds have been on the M.I.T. scene ever since. A campus-wide exhibit arranged by the Association of M.I.T. Alumnae celebrated their achievements, and the convocation of June 2-3 was a babble of voices on all the issues relating women to contemporary affairs in the U.S. today. (The picture second from the bottom, opposite, shows Mrs. Katharine Graham, President of the Washington Post Co., following her address to the convocation banquet on June 2.) (Photos: Sheldon Lowenthal, '74)

☐ This is no ordinary form of corruption; the motive was not personal greed or conventional lust for power. Watergate, said Mrs. Graham, represents "a peculiar strain of partisan and idealistic zeal," the work of "a band of zealots profoundly insecure and showing great contempt for the democratic process."

☐ Though the indictments arising out of Watergate are cited by some as evidence that "the real America survives," the fact is, said Mrs. Graham, that decency was served "only belatedly and then only because a few—very few—people refused to be put off." In fact, said Mrs. Graham, the system "did not function at all when Americans should have learned about the nature of their government," while they were preparing to vote on its continuance.

☐ "The investigation of such a tangled web of crime, money, and mischief was made harder by the President's efforts to deny and brush away," said Mrs. Graham. There was "uncomfortable pressure to cease and desist," she charged.

☐ Though the whole episode "underscores the vital importance of a free press," American newspapers need feel no sense of triumph for their role in uncovering the Watergate conspiracies. "The mission of the press is precisely to illuminate such things," and the nagging question remains: Why did so many ignore and downplay the story so long?

Now we must ask another question: What urgent national business is not being attended to; who, while the Watergate story occupies our attention, is in fact making decisions, and how?

Finally, what can be said about the future? From "our common sense of outrage must come a new appreciation of our free institutions, said Mrs. Graham, we must capitalize on this "climate of reform."

Katherine Dexter McCormick and Her Hall: "The Difference Was Immense"

Reminiscenses were the order of the day on June 3, when three generations of M.I.T. coeds traced the story of women at the Institute. Florence H. Luscomb, '09, knew Ellen Swallow Richards ('73) as a member of the faculty, a pioneering expert on food chemistry whose brilliant example encouraged other women to consider attending M.I.T. Dorothy W. Weeks, '23, continued the account of the evolution of coeducation at M.I.T., culminating with the years during which James R. Killian, Jr., '26, and Julius A. Stratton, '23—both themselves members of the Sunday morning panel—were the Institute's leaders.

Through all these accounts kept appearing the name of Mrs. Katherine Dexter McCormick ('04). A philanthropist with a stated policy of occasionally giving money to unpopular causes, she was deeply concerned with birth control and women's rights—including M.I.T.'s commitment to the education of women. The result was the gift to M.I.T. which made possible completion in 1963 of the first tower of McCormick Hall.

The difference it made, said the final speaker, Emily L. Wick, Ph.D.'51, Professor of Food Chemistry, was immense.

"Before 1960," Professor Wick told the convocation, "women entered M.I.T. at their own risk. If they succeeded, good. But if they failed—well, they weren't expected to succeed." Only a little more than a third of the women who entered in the Class of 1960 earned degrees—in contrast to about 90 per cent of the men in the same class. Four years later, with McCormick Hall completed and with new support for women throughout the Institute, the percentages of men and women completing their education in the Class of 1964 were about the same.

What of women at M.I.T. since then? Continuing change. In 1965, eight years ago, there were strict parietals; today there are none. Today there are five coeducational living groups and a woman's dormitory; in 1965 there was but one place on the campus for women to live: the single tower of McCormick. In 1964 there were no athletics for women; today coeds must complete the same athletic requirement (four seven-week courses) as men, and there are seven women's varsity teams. In 1964 the admission of women to M.I.T. was by a separate procedure, the number of acceptances being limited by the number of on-campus dormitory rooms available for them. As a result the demand for places—and the standards for acceptance—were higher for women than for men. Today the same admissions procedure applies to all applicants, male and female.

To Attain Women's Rights, Reach for Education

Only a few countries can match the record of change in the status of women which Emily L. Wick, Ph.D.'51, reported in the last decade at M.I.T. (*see above*), thinks Helvi Sipila, Assistant Secretary General for Social and Humanitarian Matters at the United Nations. The best example is that of the Scandinavian countries, Mrs. Sipila said, where the law assumes "complete equality" of men and women.

Women are least privileged in developing countries, where men have priority in the inadequate educational facilities. As a result, said Mrs. Sipila, the majority of the world's 800 million illiterates are women. It is a vicious circle: uneducated women are less likely to use birth control methods, so population growth continues in those countries which are least prepared to cope with it.

(Continued from p. 109)

tory of the world" has taken place in the U.S. since the 1940s—from the farms to the cities. We are now "a concentrated people," said Dr. Hollomon, and so we are experiencing new urban problems, "a concentration of industrial and civil waste."

□ These two factors have together made us more aware of social waste and its consequences, giving us a new sense of responsibility which we do not yet know how to fulfill. Indeed, we find it "hard to be sure that we can deal with our problems," and Dr. Hollomon has two suggestions: We know that technology is a "two-sided coin," but we must continue to extend our knowledge of the physical world and how we can deal with it; and at the same time we must "open our perceptions" so that we can better understand the values we wish to foster in our changing world.

U.R.O.P. as Innovation

The best "salesman" for the Undergraduate Research Opportunities Program (U.R.O.P.) is its founder, Margaret L. A. MacVicar, '65, Assistant Professor of Physics. U.R.O.P. was described in detail in *Technology Review* for February (*pp. 78-83*), and no summary of Dr. MacVicar's Alumni Day presentation will add to that account or convey her enthusiasm and dedication for the program, which is widely regarded as one of the Institute's outstanding recent innovations in undergraduate education.

Cancer: Time for the "Breakthrough"?

If man's knowledge of the processes of growth and development in normal cells is so "fragmentary," then how can we think that a Center for Cancer Research can lead us to the cause(s) of that form of abnormal growth which we call cancer?

Dr. Luria, Nobel Laureate who is Sedgwick Professor of Biology, will direct the new Center when it opens in the fall. He admitted to his Alumni Day audience that the processes of cellular growth are indeed obscure to us—because of their "enormous complexity" compared with physics or chemistry, for example. We literally have "no idea why a fertilized egg makes a cell of a particular kind, or why liver cells (for example) stop multiplying when the liver reaches a certain size."

How then can we expect to learn about that special kind of uncontrolled growth which we call cancer?

In 25 years, thinks Dr. Luria, we have in fact learned enough about cells and their growth processes so that a more specific approach to abnormal growth, as a fundamental problem, may be fruitful. Indeed, said Dr. Luria, our ignorance after so many years of research by uncounted numbers of biological and medical scientists may be the "most remarkable fact" about cancer.

$21 Million for M.I.T. in One Day; the President Nearly Speechless

"If I sound as if I'm boasting a little—believe me, we've got something to boast about."

David W. Skinner, Reunion Gift Chairman for the Class of 1923, was right: they did indeed. The reunion gift—the total of giving by members of the Class during the five-year period ending with the 50th reunion—was a prodigious $8,098,300. And in addition, said Mr. Skinner, 34 members of the Class have made plans for future gifts to M.I.T. the current value of which is estimated at $9,563,000.

Both figures are, of course, records—by such a large margins that they may in fact be nearly unassailable. Over 80 members of the Class had contributed to the reunion gift.

Two other classes also announced their reunion gifts to M.I.T. during the Alumni Day luncheon on June 4:

For the Class of 1948—"the megabuck class," he said—Jack C. Page announced a record number of contributors, 678, to the third highest quarter-century gift on record, a total of $597,560.

And 70 per cent of the members of the 40-year Class of 1933 joined to provide a reunion gift of $816,371, well above the $660,000 goal which the class set when the Class asked Ellis C. Littman to lead the effort beginning five years ago.

Still more good news—from Howard O. McMahon, Ph.D.'41, Chairman of the Alumni Fund Board. As of that noon—June 4—said Dr. McMahon, the 1973 Alumni Fund stands at $2,781,000—$500,000 ahead of last year at the same time. The number of donors: some 500 fewer than to the 1972 Alumni Fund as of early June; but we still hope to equal last year's record number, said Dr. McMahon, and in any case it will surely be recorded as an "outstanding year for the M.I.T. Alumni Fund," he said.

If there were no duplication—there is some—and all the figures could be added up, they would come to $21.9 million for M.I.T. Apparently thinking along these lines, President Wiesner—who said he "was rarely speechless"—nearly was.

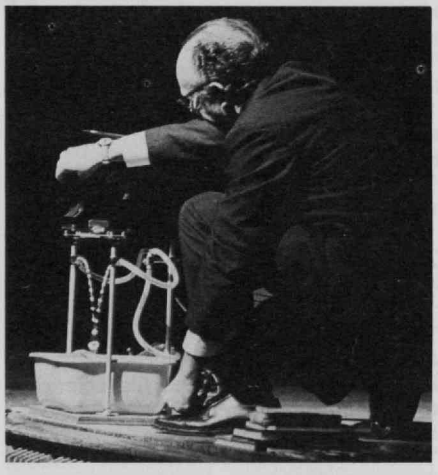
"All I can say," said Dr. Wiesner, "is that we'll try to be worthy of what the alumni here have done."

The Role of Alumni: Wisdom and Experience Through "a Gossamer Web"

Can alumni provide a body of "hidden advocacy" as important to M.I.T. as the "hidden curriculum" of nonclassroom activities is to its students?

Dr. Jerome B. Wiesner, President of M.I.T., suggested a four-point role for alumni in Institute affairs in his address to the 1973 Alumni Day luncheon, and some graduates present thought it the most outspoken proposal for alumni participation in Institute affairs in at least a decade.

Alumni, said Dr. Wiesner, can offer their alma mater "indispensable help" in funding, in selecting a well qualified student body, in fostering good public relations, and in keeping curricula in tune with current needs and with graduates' ex-



Alumni Day highlights (clockwise from Arthur Fiedler and the Boston Pops): the President relaxing with friends; Professor Harold E. Edgerton, Sc.D.'31, with his "double hydraulic happening"; James O. McDonough, '43, Chairman for the Day, conducts an informal post-mortem with Breene M. Kerr, '51, Alumni Association President; and a proud moment for Ellis C. Littman, presenting his Class of 1923's reunion gift to President Wiesner. (Photos: Sheldon Lowenthal, '74, and Susan Pogany)

periences.

The reports of the Alumni Fund and reunion gifts given at the Luncheon (*see above*), said President Wiesner, "speak eloquently for alumni financial contributions." But he also noted the contributions of alumni to M.I.T.'s physical plant—the Rockwell Cage in which he and his audience sat, the du Pont gymnasium, buildings bearing such names as Green, Whitaker, McCormick, McGregor, Dorrance, Sloan.

Indeed, said Dr. Wiesner, "without the contributions of alumni there would be no M.I.T. today."

The alumni role in admissions is fulfilled chiefly by some 1,000 Educational Counselors; they have interviewed "more than 80 per cent of all the freshmen who have entered M.I.T. in recent years," said President Wiesner, and they are also responsible for "organized contact with nearly 3,000 preparatory and secondary schools" throughout the U.S.

A "Gossamer Web" of Communications

But it was on the matter of "alumni expertise and counsel" that Dr. Wiesner was most outspoken. "The alumni collectively and individually represent an immense pool of experience and knowledge which is of enormous help to M.I.T.," he said. "Their judgment is seasoned from years of professional service—and if often bears directly on many of the problems of the Institute."

In addition to the formal approaches of alumni membership on Corporation and Visiting Committees, said President Wiesner, there is "a sort of gossamer web of communications representing a myriad of informal contacts . . . which help keep M.I.T. in touch with social, economic, and technological trends and needs . . . and contribute to the process for determining objectively the effectiveness of the Institute's program.

"It is here," continued President Wiesner, "that I hope the Alumni Association can begin to develop a more formal and orderly fabric—one that assures the distant alumnus that his voice is heard and that he is being listened to.

"We need many more opportunities through innovation for our alumni to take part first hand in the affairs of the Institute."

Traditional Excellence in Technology

Summarizing recent events at the Institute, Dr. Wiesner assured his alumni audience that 1972-73 has been a good year for M.I.T.

"We have a better idea, I think, of how M.I.T.'s resources can be used to continue our leadership in science and engineering, by maintaining its traditional excellence in these disciplines while contributing to new understanding of how they affect us all.

"M.I.T. has never swerved from its objective of the advancement of science and its practical applications," Dr. Wiesner declared; and he pledged the Institute's "strength and flexibility continuously to adapt its procedures and vary its emphases to meet the changing needs and opportunities within this mission."

Breene M. Kerr, '51, President of the Alumni Association, and Laya Wiesner, the Institute's First Lady, took obvious pleasure from the ceremony in which she became an Honorary Member of the Alumni Association during the Alumni Day luncheon on June 4.

The President Joins the Alumni In Praising Their First Lady

When Laya Wainger graduated from high school in Johnstown, Pa., nobody thought to suggest that she might come to M.I.T. So, she explained to the Alumni Day Luncheon audience, "I took another time-honored route."

It was a route that led not only to Cambridge—but eventually to the role of M.I.T.'s First Lady and, on June 4, to Honorary Membership in the M.I.T. Alumni Association. The announcement was made by Breene M. Kerr, '51, President of the Alumni Association, who handed Mrs. Jerome B. Wiesner an appropriate certificate to assure her of her newest status in the Institute community.

Mrs. Wiesner said she was "terribly honored—really very pleased."

So was President Wiesner, who assured in his turn those present that Mrs. Wiesner would make "a good alumna."

"I rarely have a public opportunity to say how great she is," he said.

Class of 1923: The Experts on Putting Your Name on a Building

"There are two ways to have a building named after you," said Uncas A. Whitaker, '23, at the earth and life sciences program of the 50th reunion of his class on June 2.

"The easy way and the hard way.

"Cecil [Green] and I did it the easy way. Jay [Stratton] did it the hard way.

"You can find out how to get your name on a building from Irwin Sizer and Bob Shrock, who is the most expensive friend Cecil Green ever had."

The last remark broke up the Class of 1923, which has given names to four major M.I.T. buildings. At the dedication of the fourth of the group, the Tang Residence Hall (*see page 108*), Howard W. Johnson, Chairman of the Corporation, noted that "about 10 per cent of the total floor space of the Institute bears the Class of 1923 imprint."

In addition to the four buildings, the class is identified with the patio garden fronting the M.I.T. Alumni Pool. But it will also be remembered for its monumental reunion gift reported at the Alumni Day Luncheon on June 4 *(see page 112)*.

Other contributions to the Institute, too, said Mr. Johnson at the Tang Building dedication on June 1: the Class of 1923 has given 11 of its members to the M.I.T. Corporation, and 67 have held faculty posts.

At a program to celebrate its contributions, members of the Class attending the reunion heard about the remarkable growth of the earth and life sciences in the past 50 years at M.I.T. Dr. Shrock, Professor Emeritus of Geology, pointed out that the Department which he formerly headed—now called Earth and Planetary Sciences—has grown since 1923 from five professors to 40, from 12 undergraduates to 70, from seven graduate students to 165, and from annual budgets of $50,000 to $5 million.

Professor Samuel A. Goldblith, '40, Deputy Head of the Department of Nutrition and Food Science, summarized that Department's $4.5 million program of research activities. But, said Irwin W. Sizer, Dean of the Graduate School, it was not always thus. Going back a full century, it all started when a frustrated President William Barton Rogers offered the Institute's governing board a percentage of his own magnanimous $2,100 salary for a biology professor. His proposal was accepted. But even then President Rogers, himself a geologist, put in some hours teaching biology in order to keep the "department" alive.

A very different struggle was recorded by Kenneth R. Wadleigh, '43, Vice President of the Institute, and William H. Byrn, Jr., '66. Professor Wadleigh was Dean of Student Affairs while the Student Center was being designed and built, and Mr. Byrn was chairman of the student committee involved in much of the planning—and in the decision to name the building in honor of its chief protagonist.

Having established their reunion headquarters at the Marriott Motor Hotel in Newton, members of the Class of 1923 were kept busy negotiating the steep steps of chartered buses to and from the campus events planned by Herbert L. Hayden and Thomas E. Rounds. More than 150 members of the Class and their wives attended.

A 25-Year Report on 1948: Hard-Working, Successful, Conservative

Twenty-five years later, 80 per cent of the Class of 1943 would do it again. But more than 85 per cent of those who replied to their 25th-reunion questionnaire said they were reaching their goals, living "at least as well as expected" when they left M.I.T.

Those statistics have little to do with what happened when over 100 members of the Class—because of World War II, one of the largest in the history of the Institute—came back for four days on the M.I.T. campus June 1 to 4 this spring. Two very different kind of records stand out from those days:

☐ A hole-in-one at the Essex County

These pictures prove what you knew already: 50- and 25-year reunions are really very different. The Class of 1923 (above) celebrated with an emphasis on formality: the traditional class picture, a reception at the President's House, and a program celebrating the contributions of their classmates to the Institute—the Green, Whitaker, Tang, and Stratton Buildings. (In the picture immediately above, Professor Samuel A. Goldblith, '40, describes food science studies in the Whitaker Building.) Meanwhile, the highlight for the Class of 1948 (below and right) was a day of tennis, golf, fishing, and clambake at the Essex County Club; the day's largest fish was the catch of Erin Finnegan. (Photos: Roger N. Goldstein, '74, and Sheldon Lowenthal, '74)

Club, whose pro says it may never have happened before; to celebrate that event, President Jerome B. Wiesner found a copy of "Down Hill Lies and Other Falsehoods" for Jack C. Page, who made the lucky shot.

☐ Eleven members of the class play softball just exactly as well as eleven of their offspring—a conclusion to be drawn from the tie score in the father-son game on June 3.

It was the largest on-campus reunion ever held at M.I.T.; and the Class' gift to M.I.T.—a total of $597,560, the third largest quarter-century gift on record—came from 678 donors, more than have ever before given to a class gift to the Institute. Reunion spirit—also high—cannot unfortunately be measured so quantitatively.

Some data about the Class, from 400 replies to the 25-year questionnaire organized and tabulated by Herbert D. Marcus:

☐ Less than 20 per cent of the Class has been with a single employer since graduating from M.I.T. Half have moved once, twice, or three times in their careers, and 25 have held eight different jobs.

☐ Twenty—just 5 per cent—have already retired; 80 per cent of the others bring work home from the office at night, and 70 per cent of those spend at least three hours a week on it.

☐ One hundred members of the Class—just 25 per cent—replying to Mr. Marcus' survey describe themselves as entrepreneurs, and 85 more said they wanted "to run my own firm" but hadn't managed it yet.

☐ Of the 400 surveyed, 115 members of the Class of 1948 put their earned incomes for 1972 in the $26,000-to-$35,000 bracket. But 125 of them said their average net worth over the past two years had been between $51,000 and $100,000, and 150 of them have some $100,000 of life insurance in effect. More than 25 per cent live in homes whose current market price they estimate at $56,000 to $80,000.

☐ Just 360 of the 400 are married, and only 30 have been divorced.

☐ More than half the Class are Republicans (though 40 per cent said they were "capable of putting a few checks in the Democratic column"), 15 per cent are Democrats, and the rest are independents or Socialists (four out of 400).

☐ Just over 1 per cent of the Class have no television, but only 6 per cent have color TV sets.

☐ Seventy-five per cent do not smoke.

Individuals Noteworthy

John Harbison, Associate Professor of Music at M.I.T., is one of six musicians commissioned by the Serge Koussevitzky Music Foundation in the Library of Congress for musical compositions. . . . **Emily L. Wick**, Ph.D. '51, Professor of Food Chemistry, will leave M.I.T. this summer to become Professor of Chemistry and Dean of the Faculty at Mt. Holyoke College. . . . **David Davies**, for three years Leader of the Seismic Discrimination Group of Lincoln Laboratory, has been named to edit *Nature*, the distinguished British journal of international science.

To **Peter W. Huber**, graduate student in mechanical engineering at M.I.T., the Joseph W. Barker ('16) Fellowship in Engineering of Research Corp., the first time the national fellowship award has come to the Institute; it honors the founder of the New York-based foundation for managing technological innovations from U.S. campuses. . . . Two-year Sloan Research Fellowships of the Alfred P. Sloan ('95) Foundation to four members of the M.I.T. faculty: **Carleton DeTar**, Assistant Professor of Physics; **Michael S. Feld**, '63, Assistant Professor of Physics; **Norberto Kerzman**, Assistant Professor of Mathematics; and **K. Barry Sharpless**, Assistant Professor of Chemistry.

University Appointments

To the Faculty of Medicine at Harvard University: **Edward R. Loftus**, '33, to Assistant Clinical Professor of Peridontology; **Roger G. Mark**, '60, to Assistant Professor of Medicine; **Warren M. Zapol**, '62, to Assistant Professor of Anaesthesia; **Ernest S. Kuh**, S.M.'50, to Dean of the College of Engineering on the Berkeley Campus, University of California. . . . **Forbes T. Brown**, '56, to Professor in the Department of Mechanical Engineering and Mechanics, Lehigh University.

Research and Development

Robert C. Casselman, '39, has been elected Senior Vice President and Director of a newly-formed division—Government and Institution Services—of Rath and Strong, Inc. Mr. Casselman, former Polaroid Vice President, was consultant to the Commonwealth of Massachusetts on government reorganization from 1967 to 1971 (*see "The State of State Management" in* Technology Review *for January, 1973*). . . . **Robert B. Davis**, Ph.D.'66, has been named Assistant Director of Fabric Research Laboratories, Inc., providing research and consulting services in textiles, plastics, paper and related materials. . . . **Sarsfield McNulty**, '58, has been named Manager, Technical Programs, in the Research and Engineering Division of Xerox Corp. . . . **Frederick J. Ross, Jr.**, '46, Group Vice President, Abrasive Systems, The Carborundum, Co., has been elected a member of the Executive Committee of the American Supply and Machinery Manufacturers' Association, Inc. . . . **Daniel L. Ross**, Ph.'59, has been appointed Head of the Research Group on Organic Materials and Devices at the R.C.A. Laboratories in Princeton, N.J.

Awards

N.A.S.A.'s Group Achievement Award for the traverse gravimeter built at the Charles Stark Draper Laboratory and carried to the lunar surface on Apollo 17: **John B. Harper, Jr.**, '50 led the design and development of the instrument as program manager; **Sheldon W. Buck**, '59—also of the Draper Laboratory—was Program Director; and **Manik Talwani** of the Lamont-Doherty Geophysical Laboratories of Columbia University was Chief Investigator. . . . **Thomas K. Meloy**, '17, was given the "Engineer of the Year Award" by the Engineering Societies of Washington, D.C. He responded with an address proposing "it is time for an engineer to do something about cancer." In fact, said Mr. Meloy, he already has: "Our cancer laboratories are more mechanical than a factory." . . . **Henry Miller**, '69, University of California at San Diego medical student has received the second place "excellence in research" award at the 13th Annual Student American Medical Association-University of Texas Medical Branch National Student Research Forum. Mr. Miller described his research at the forum as identifying and characterizing a previously undefined bacterial enzyme—Ribonuclease H.

Deceased

Archibald L. Klieves, '01, February 18, 1971
G. Huntington Clapp, '03, April, 1965
William B. Boggs, '04, November 24, 1972
Patrick J. Sullivan, '05, March 13, 1973
John T. Wrinkle, '06, April 7, 1973
S. Gilbert Emilio, '07, February 20, 1973
George A. Abbott, '08, April 16, 1973
Christian Kurtzmann, '09, December 2, 1972
Samuel L. Hayes, '11, n.d.*
Bertrand F. Brann, '12, May 16, 1972*
Jabez H. Pratt, '12, March 12, 1973*
William R. Mattson, '13, May 17, 1973
Seaphes D. Shinkle, '13, July 12, 1971
Philip B. Terry, '13, March 22, 1973*
Charles F. Thompson, '14, January 24, 1973
Bradford Curtis, '16, March, 1973*
Howard A. Hands, '16, May 2, 1973
Harold Larner, '16, April 12, 1973
Gale D. Goepfert, '17, February 7, 1973
George O. Ekwall, '18, June 24, 1972
Edmund W. Hill, '19, May 1, 1973
Kenneth A. Wright, '19, March 14, 1973
David L. Fiske, '20, April 30, 1973
Edmund C. Sullivan, '20, n.d.
Harold O. Bixby, '21, April 23, 1973
Earl H. McBroom, '21, June 30, 1972
M. Ewart Hurst, '22, n.d.
Paul M. Kellogg, '22, April 26, 1973
Bennett Myers, '22, August 1968
Lloyd E. Raymond, '22, n.d.
John F. Pierce, '22, October 24, 1972
Clarence H. Chaisson, '23, April 29, 1973
George H. Hurley, '23, February 22, 1973
Edward R. Barnes, '24, n.d.
Gordon F. Eaton, '24, March 7, 1973
Frederick W. Fulle, '24, April 9, 1973
Wheeler G. Lovell, '24, November 28, 1971
Edwin A. Smith, '24, n.d.
Dana Staples, '24, November 1972
J. Marshall Osborne, '25, April 3, 1972
James Q. DuPont, '26, n.d.*
Edwin J. Gohr, '26, March 9, 1973*
Gostan Gostanian, '26, n.d.*
Grandison Gardner, '28, January 19, 1973*
Charles F. Haberstrok, '28, August 28, 1972
Melvin Sack, '28, April 16, 1973
Richard D. Wilhite, '28, January 29, 1973
John F. McGrath, '29, January 19, 1972
David M. Goodman, '31, December 13, 1972
Meyer White, '31, November 5, 1972
Daniel F. Neilon, '32, March, 1973*
Henry J. D. Meyer, '32, March 4, 1972
Harrison L. Jewett, '33, April 27, 1973
Edward P. Oxnard, '33, May 21, 1971
Peter Barry, '34, n.d.
George H. Hunt, '35, April 10, 1973
Richard L. Moses, '35, April 6, 1971
George F. M. Chase, '38, January 13, 1973
Percy H. Brown, Jr., '40, March 8, 1972
Owen W. Matthews, '40, December 13, 1972
Don Coppersmith, '72, December, 1972
*Further information in *Class Review*

Class Review

96

This month's news item is due to the efforts of one of my students who was awarded a certificate of merit by the local branch of the American Society for Metals. We, student and teacher, were invited to the annual dinner at which presentations are made to outstanding professionals as well as to the students whose Science Fair projects were chosen for recognition. The first, and evidently the highest award, made that evening went to the member whose work for the past five years had been outstanding. This was the Burgess Award and it is given annually in memory of **George Kimball Burgess**, '96. Dr. Burgess had been the President of both the local and national organization as well as the Director of the Bureau of Standards.—**Clare Driscoll**, Acting Secretary, 2032 Belmont Rd., N. W., Washington, D.C. 20009

98

Alvan Davis is having a pleasant time residing at Grove Manor in Waterbury, Conn. He reports that he is feeling well but did have poor health for three weeks in January. He continues to play checkers and to win most games! His physical activity is limited to walking short distances.—**Mrs. Audrey Jones Jones**, Acting Secretary, 232 Fountain St., Springfield, Mass. 01108

03

Now that the recent Commencement and Alumni Day, June 4, are over, the aftermath leaves lingering memories of M.I.T.'s prominence in world Science and Engineering.

We received a very enlightening letter from classmate, **Charlie B. Cox** of Wenatchee, Wash., who writes, "I am always pleased to read of the interesting career of any classmate in the Class Notes. Accordingly, I am enclosing some of my own experiences regarding the Columbia River, on the bank of which I live. It is here my wife and I are still living where I retired from government service in 1950. Aside from spending considerable time with the senior citizens groups, I watch with much interest the changes of the river from a rapid flowing stream, into a continuous series of lakes, utilized by the construction of ten, large power dams, that embrace the land from Portland, Ore., to the Canadian border—some 500 miles.

"When I first saw the Columbia River in 1903 and made a measurement of its flow at Pasco, low water stage, in October (63,000 feet per second) there was then not a dam on the river until The Bonneville Dam which was built around 1930. This was followed by the Rock Island Dam and Grand Coulee Dam construction about 1934. Seven more dams have been built between Bonneville and Grand Coulee making the Columbia River the greatest producer of hydroelectric power in the world.

"This river has another unique value; it maintains a high discharge through the summer months when most rivers are at their lowest flow. The reason for this, is because of the condition in the Canadian head waters of the Columbia River. Here there are some 1200 square miles of snow fields and when the weather gets hot in July and August, these fields melt faster and keep the river discharge high. The water is unusually cold and a wonderful stream for migrating salmon. Several million salmon of six species enter the mouth of the Columbia River annually, to spawn in the main river and its many tributaries.

"Before the dams were built on the river, some of the big chinook salmon used to swim up the full 1200 miles to spawn in the river's source—Columbia Lake. They were badly battered yet were able to spawn and fulfill their destiny. All salmon die shortly after spawning, so it is only the young from the eggs that are laid and covered by gravel, that return to the ocean and keep the life cycle continuous.

"Grand Coulee Dam, on which I worked for 16 years, stopped the salmon from going any further up stream to spawn but there are still some 125,000 salmon that annually spawn above Wanatchee, so I find the Columbia a most interesting and fascinating stream to live near.

"My good health still continues. My only trouble is that after two cataract operations I can only read with difficulty—yet see well enough to walk about town safely. As our Class survivors diminish, I somehow feel a closer, warmer friendship for the few who are fortunate to remain. My best wishes to you and your family and continue your cherished Class news without end."—**John J. A. Nolan**, Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

04

The only news we have this issue to report is three deaths. **Moise H. Goldstein** of 1309 Felicity St., New Orleans, La., on December 28, 1972 and back in October 1967 **Albert C. Ferry** of Townsend, Mass. . . . **William B. Boggs** of 124 Mineola Rd., Port Credit, Ontario passed away on November 24, 1972.—**Eugene H. Russell**, Secretary, 82 Stevens Rd., Needham, Mass.

05

Ruth and I have just returned from a month's visit with our daughter Lucy in Greensboro, N.C.—beautiful country. If I couldn't live in New Hampshire, I could quite readily choose North Carolina. After being pampered so long it's hard getting back to routine. While in Greensboro, I received a letter from **Charlie Mayer**, Course IV, telling of a trip East to attend the wedding of a granddaughter, the daughter of Mr. and Mrs. George Gow, whom many of you have met at our Five Year reunions. He also wrote that he would plan to visit us in New Hampshire. Unfortunately, this was not possible, since Charlie had come and gone before our return home. The message here is probably that Charlie, at 93, was able to make the two cross-country trips and still remain in good health.

Chester Shaw, Course VI, sends a clipping telling of the death of Mrs. Robert McLean. Those who attended our Reunions will remember that Bob and Jennie added much to the occasion. In talking with **Art Balkam** about attending Alumni Day, I learn that his health is such that he will be unable to.

We received late word through the Alumni Association office that **Patrick Sullivan**, Toms River, N.J., died on March 13, 1973. Pat was with us only two years; I do not remember him, but he showed his class loyalty by contributing to the treasury.—**Fred W. Goldthwait**, Secretary, Box 231, Center Sandwich, N.H. 03227; **William G. Ball**, As-

sistant Secretary, 6311 Fordham Place, Bayshore Gardens, Bradenton, Fla. 33505

06

Letters are few and far between, but we have heard from two Bobs recently, one from the West Coast and the other from the East Coast. On March 20, I received a long, interesting letter from **Bob Cushman** from Portland, Ore., and on May 11 from **Bob Rose** from Marblehead, Mass. The western Bob is a confirmed optimist, it would seem. Referring to the assertion in the February notes that "we are now old men", he says he doesn't entirely agree. "To me, precious memories of happy events in the past, supplemented with daily pleasures and the joy of many friendships, give me a sense of *everlasting* youth."

Bob's 89th birthday on March 10 was celebrated by many friends; a long distance call; a birthday cake, and a close friend, a fellow Odd Fellow, took him to a lodge meeting, then to a supper meeting where his birthday was noted and he responded, and they sang Happy Birthday. "I must admit that by Sunday night I was a tired man, but *I did not feel old.*" Bob said his most prized birthday present was a letter from the State Motor Vehicle Division stating that the State Public Health Officer had given a favorable report so his driving license was renewed. but he doesn't drive at night now. A long A letter he had received, related to past memories. 'When we count happy memories we cease to count years.'

The other Bob was **Bob Rose** who wrote that he had cancelled his reservations nor Alumni Day because of his health. He manages to get around for local errands and events but realizes that Alumni Day would be too much for him and Anne. "We are in good health, for old folks, and hope you and Marion are also." Thanks Bob, Marion and I are quite well too though Marion has had retinal degeneration resulting in impaired vision, which somewhat curtails our social and other activities, though we still get about with kind friends, taxis, and the Minibus for Wellesley Senior Citizens. So we do not plan to attend Alumni Day either."

There are two deaths to report. **John Timothy Wrinkle** was born in Plattsburg, Mo., on April 5, 1883 and died April 7, 1973, in a Springfield, Massachusetts nursing home. John prepared for M.I.T. at Holyoke High School and his home address continued to be Holyoke. He obtained his undergraduate degree in Architecture with our Class and continued to earn his M.S. with '07. He was a member of the art staff of the '06 *Technique* and his thesis was on a "Terminal Station for the City of Boston". He soon obtained employment as a draughtsman in Boston and I believe he roomed at Technology Chambers (of fond memory). Later he had his own office in Holyoke; by 1925 was a designer with H. L. Sprague in Springfield and continued with that firm until around 1940 when he was employed by the city, in several departments, during which time he designed several town buildings. By 1955 he had his own office as architect in Mill River, Mass., where he was living in the old family homestead, really retiring in 1967. On November 26, 1921, John married a first cousin, Mary Wrinkle, who survives him. They had four children and 23 grandchildren. In 1971 the Wrinkles celebrated their 50th anniversary at the home of a son at a family gathering. A note of sympathy has been sent to Mrs. Wrinkle. John and I had some recent correspondence. They have spent the winter months in Florida for some years.

Carroll Andrew Farwell was born September 13, 1883, in Bolton, Mass., and died May 20, 1973, in Sharon, Mass. While at M.I.T. his address was Canton, Mass. He prepared at the Chester, Vt., Central High School, was a member of the M.I.T. C. E. Society and was on the '06 Tug-of-War team. He obtained his B.S. degree in Chemical Engineering and his thesis was on the efficiency tests on rifle hydraulic engine. Carroll soon joined the well-known engineering firm of Fay, Spofford and Thorndike with several Boston addresses through the years. His entire business life was with this firm.

In 1964 he told me that he went to the office now and then but had his "limitations". In 1945 at its 97th annual meeting, the Boston Society of Civil Engineers elected Carroll its next President. Carroll married Alice Sargent who died April 6, 1964, and they had three daughters, all living in Sharon, in '64. As a couple, Alice and Carroll attended Reunions in 1936, '46, '51, and '56. Carroll was a loyal M.I.T. man and classmate through the years. A note of sympathy from the Class has been sent to the Sharon address.—**Edward B. Rowe**, Secretary-Treasurer, 11 Cushing Rd., Wellesley Hills, Mass. 02181

10

Jack Babcock, Course I, has sent me the following notes about the "retirement" activities of **Fred Lufkin,** VI, and himself. He writes: "Fred and I now live in Portland, Maine, and see a lot of each other. When we attended M.I.T. we had only a 'nodding' acquaintance, perhaps starting at the old Irvington St., armory where we both marched weekly with the 'exalted' rank of corporal in the freshman battalion of 1906-07. After that, we saw little of each other since we took different courses. About 50 years later, we ran across each other at a dinner meeting of the local alumni club in Portland. Fred had worked in Boston and in various places in the Mid West and had finally returned to his native city of Portland, a few years before he retired. After graduation, I went to Canada and was employed on dam and railroad construction for several years. In 1916 I returned to teach in the civil engineering department of M.I.T., just about the time the Institute moved across the river to Cambridge. I remained there until my retirement in 1959. Then I moved to Portland, a city I had always liked and where I had several good friends. I had inherited a summer cottage at Prout's Neck, a nearby vacation spot on the sea coast. For the past ten years or so, Fred and I have been very close friends. We are both widowers and in fairly good health for our age group. Fortunately we both still drive. We also lunch together twice a week and take occasional automobile trips to points of interest in Maine. Fred, being a native of this area, has numerous relatives and friends here. He is quite active in several groups affiliated with his church. All told, he keeps busy!

My own activities are mostly connected with alumni affairs. Besides serving as Class Agent and Reunion Chairman for 1910, I am Secretary of the M.I.T. Club of Western Maine (centered around Portland) and arrange our spring and fall dinner meetings. Fred helps me a lot in connection with theme alumni activities. He is an excellent typist. He types (and helps edit) my sometimes illegible handwritten notices and letters. Quite a bit of my time is devoted to correspondence with a number of my former students in the civil engineering department during my 40 years there. In recent years, Fred and I have enjoyed brief visits (at least long enough for a luncheon together) from several 1910 men and their wives. These include **Allen Gould** of Cleveland, Oh., **Carl Lovejoy** of Boynton Beach, Fla, and **Walt Spalding** of Honolulu. (N.B. Fred has kindly typed these notes)."

Mrs. Merrill William Tilden writes the following: **Merrill William Tilden**, 83, of 1102 Judson Ave., Evanston, Ill., 60202 died February 1 in Evanston Hospital of emphysema and pneumonia. He graduated from M.I.T. in 1910, a member of Osiris. He had lived in Evanston for the last 18 years and retired this year as Vice President of Mitchell Hutchins, a brokerage firm in Chicago. He is survived by his wife of 62 years, Laura Prett Tilden, a daughter, Virginia Burnham and two grandchildren.

I have received 37 letters from the surviving members of the Class of 1910. I also received returned envelopes with notes and new addresses of eight classmates. **W. R. Dray** simply noted his return address: P.O. Box 178, Yorkville, Ill. 60560. . . . **Roger F. Hill** is retired and restricted to the house. . . . **Alva B. Court** changed his address to 705 Americana Dr., Annapolis, Md. 21404. He has just retired and had an operation for cataracts. . . . **Leroy Briggs**—no news, except his birthday October 21. He will be 86 years old.

J. Brewster Hooker writes as follows: "I am living in retirement in my home on the shore of a small lake here (Interlacher, Fla.). My wife died in 1959. For more than 20 years I worked on Wall Street, New York, most of the time with one of the large banks. . . . **Walter S. Davis** wrote a letter enclosing a check to the Alumni Fund which I sent to **Jack Babcock** who is in charge of all funds collected by the Class. . . . **George P. Lunt** maintains a small office in Boston where he does some Consulting Engineering work.

Atwood C. Page of 620 Weir St., R.F.D. 3, Glastonbury, Conn. 06033 died March 7, 1973.

I contacted Charles R. Wallover by phone and he seems to be OK. He is the oldest member of our Class.—**H. S. Cleverdon**, Secretary and Treasurer, 35

Windemere Rd., Wellesley Hills, Mass. 02181

11

Since reporting **John Alter**'s death in May, I have received the May *New England Architect* from which the following is taken. After receiving his master's degree from M.I.T. in 1912 John spent three years in the office of James E. Allen in Lawrence and then four years teaching in Chicago. In 1920 he returned to Lawrence and the firm of Ashton, Huntress and Alter which planned a number of schools, public buildings and residences. From 1945 until his retirement John was a member of Pearson, Alter and James, doing residences, commercial work and housing projects. His greatest interest was in the Boston Architectural Center and he is credited with keeping the Center alive during the great depression and World War II days. For 20 years he spent one day a week teaching first year design there. He was a member of the Center's Board of Directors and when the John Worthington Ames Scholarship was established John was made its permanent secretary.

In a recent letter from **Paul Cushman** he told me he has recovered nicely from his broken hip of two years ago and is planning on living for many more years. From clippings that he enclosed I get an outline of his remarkable career. Mechanical Engineering Department. University of Arkansas, 1924-5; Vanderbilt University, 1928-31 and Valparaiso University, 1933-38. High Priest of Valparaiso Chapter of Royal Arch Masons, 1947; Worthy Patron Valparaiso Eastern Star, 1947; President of Valparaiso Community Concerts 1942-47; President of Valparaiso Youth Center, 1942-47; President Valparaiso Foreman's Club, 1943; Chairman Valparaiso Community Chest, 1945-47; Chairman of Boy Scouts for Valparaiso District, 1945-46 and of their Building Relocation Committee; test engineer and metallurgist, McGill Manufacturing Co., Bearing Division, Valparaiso, Ind., 1938-47 after part time with them, 1933-38; taught evening courses in mathematics and metallurgy at Purdue University in Valparaiso and Michigan City for many years. From 1948 to 1959 Paul was Professor of Mechanical Engineering at the University of Oklahoma. For five of these years the University had him at Tinker Field as Associate Director of Research on Ball and Roller Bearings; Chief Engineer and Metallurgist at L and S Bearing Co., Oklahoma City 1947-66 on part time while he was a professor at the University. Paul has had a number of papers published and has recently finished a course in mathematics which he thinks worthy of publication.

At the time General **George Kenney** moved to Florida I reported his changed address incorrectly. It should have been: 10180 W. Bay Harbor Dr., Bay Harbor Islands, Fl., 33154 . . . At a recent call I made on Gertrude and **O. W. Stewart**, he told me that they have had eight grandchildren in college the past year.—**Oberlin S. Clark**, Secretary, 50 Leonard Rd., North Weymouth, Ma. 02191

12

I was pleased to receive a visit in April from **Henry Foley** and his wife, who had been staying with their son, Arthur and family, nearby in Valley Forge, Pa. We reminisced regarding various classmates and events during the good old days of 1912 and looked at slides and pictures of various classmates.

Fritz Shepard wrote that he is holding his own with the arthritis and that he and Betty hope to spend the summer in Marblehead as usual. . . . **Harold Mitchell** and Mildred report that they are in reasonably good health. Last winter they took an auto trip to Florida but found the traffic heavy and many new condominiums which had reduced the area where birds could be watched. They encountered unusually heavy rains in Tennessee. . . . **John Barry** says that they stayed home during the winter and that there was practically no snow on the south shore of Massachusetts. They are both in good health. . . . **Nelson Breed** and Marge took a Caribbean trip of three weeks last winter, followed by a visit to Isle of Capri, Fla., where they reported poor fishing. They are both in good health and plan to summer as usual at their home on Block Island. . . . **George Brigham** and Ilma took a visit to Pasadena, Calif., where they lived back in the twenties. They found a few friends still living there and were entertained. George is now doing little work on his building design program, due mostly to the financial situation. He is quite well, although Ilma has been suffering from protracted "flu". . . . **Jack Connolly** writes from Florida that he is in good health but is staying close to home during the winter so has no special news. . . . A brief note from **Mac MacCormack** says that he still continues to enjoy his new home in Salisbury, Md. He is in reasonably good health, and despite wobbly knees, has been doing a bit of gardening. . . . **Hattie Haub**, who is our oldest classmate at 92 years and our only co-ed, is still able to get about and sends her greetings to the Class. . . . **Paul Tyler** says that he has no special news but that he and Katherine manage to keep busy locally.

Phil Dalrymple and Helen are in good health. Phil is still working as consultant with Jackson and Moreland which keeps him well occupied. They expect to summer in Maine as usual. He advises of two recent family weddings—a grandson and a granddaughter. . . . **Jerry Hunsaker**, unfortunately, sustained a broken hip bone last year and now has to use a cane. This did not deter him from taking his usual trip to Grand Lake, Maine, this spring, where he could still troll successfully for fish. Jerry advises that he now has two great grandchildren. . . . **Fred Busby** writes from Watertown, Mass., that all is going well except for an auto accident last March in which he severely injured his nose. . . . Clarence Woodward writes that he and his wife are keeping well and that he has recovered from a back injury caused by shovelling snow last winter. His daughter and husband have just returned from Brazil, where he had been plant manager for Union Carbide.

The following men have taken trips abroad the past year or are planning for another. Still lots of kick in the old motor. . . . **Lee Bailey** writes that he is in excellent health. Last year he travelled with his wife to Norway, Sweden and Denmark and enjoyed the trip greatly. . . . **Jesse Hakes** and Mary returned, last April from a 3½ month cruise on the *Gripsholm* covering parts of Africa, India, Singapore, Hong Kong and Japan, then to Hawaii, Acapulco, the Panama Canal, Christobel and New York. . . . **Dorothy Cremer**, widow of Randall Cremer, was on the same trip. . . . **Wally Murray**, who last year took an unusual trip to the arctic, spent the winter uneventfully in his new home at Sebago Lake, Maine. This summer he is planning a ten-weeks-trip to London and then to Russia, including Siberia, Mangolia and the Gobi Desert on the Manchurian border, and on to the Pacific coast. From there he plans to cruise to Tokyo and then fly to Anchorage, Alaska, covering most of this state, and ending by cruising to Seattle via the Inside Passage,—then home to Maine. Quite a trip, Wally! Good luck!

A brief note from Harold Manning. He reports that he and Helen are well but have no special news. **Henry Babcock** writes from California that he and Ruth are both well and that they are still licensed auto drivers. They celebrate their 56th anniversary this month and hope to have many of their four daughters, ten grandchildren and two great grandchildren present. Henry is still active as an investment property consultant and is completing his second book on the subject. He invites any 1912 classmate to visit him at their summer home in Goshen, Mass., next September if they are in the vicinity.

This column was written before our Mini Reunion in June and I am hoping that a goodly number will be present. You will note that I received letters from over 30 classmates in reply to my letter of April 1, as printed in these last two issues.—**Ray E. Wilson**, Secretary, 304 Park Ave., Swarthmore, Pa. 19081

14

A few classmates have been kind enough to tell me what they've been doing recently. I just wish that a lot more would do likewise, so that these Notes could begin more often with something cheering.

Don Douglas writes that he is doing some local boating in his small diesel cruiser, and so has occasion to tie a "bowline-in-a-bight," a knot he taught me in a drafting-room interval in Engineering B. . . . **Johnny Leathers** refits Kentucky rifles, and inscribes whales' teeth with representations of ships from old prints. He finds that he can trade the scrimshaw for oil paintings by local artists. . . . **Alden Waitt** reported in April that he'd just spent the busiest six weeks since he retired from active service—the opening of a new museum wing, a large exhibition of paintings, a

teaching visit by a Canadian artist, a visit by his daughter and her children (four generations now in the Waitt family), and the completion of a landscape, "Winter's Brief Visit to Houston 1973."

Chester P. Davis died on May 3, 1973, in Arlington, where he had lived for many years. He was a member of our Class from the beginning and graduated with us in Course X. After service in World War I, he joined the Frank H. Davis Co., machine manufacturers of Cambridge and eventually became its president. He retired in 1970. Chester was a member of Hiram Lodge, A.F. and A.M., and of the Winchester Country Club. He is survived by his wife, the former Esther F. Barickman; a daughter, Elizabeth D. Martin, of Andover; a son, Chester P. Davis, Jr. of Arlington; a sister, and six grandchildren. . . . Colonel **Ernest L. Osborne** died at his home in Washington, D.C., on March 20, 1973, at the age of 83. After graduating from Yale, he was with us in our senior year, and received his M.I.T. degree in Course I. Later he received a degree in accounting from Pace Institute, and one in law from LaSalle Extension University, and did graduate work at Columbia. In World War I he was a lieutenant in the A.E.F., and from 1916 to 1919 he was a major in the Corps of Engineers, in France. Between the two world wars, Colonel Osborne remained in the Army Reserves. From 1921 to 1929 he was in charge of merchandising and management statistics with the James W. Eadie, Jr., Co., of Boston; was comptroller of Hahn Department Stores in New York City in 1929 and 1930; and was Comptroller, Secretary and Treasurer of Dictograph Products Co., in that city from 1931 to 1933. From 1934 to 1940 he held important positions in the National Recovery Administration, the Department of Commerce, the Interstate Commerce Commission, and the Social Security Board.

After his recall to active duty in the latter year, Colonel Osborne served in field artillery units in Europe and in the Pacific until 1949, and later as a civilian management engineer in the comptroller's office of the Department of Defense; he retired in 1961. In 1959 he was awarded the Certificate of Achievement for civilian service by the Department of the Army. As Vice President of the M.I.T. Club of Washington, Colonel Osborne, almost singlehandedly, increased its paid-up membership by half, and helped in other ways to revitalize it. In so doing, he telephoned at least a thousand alumni. He was a founder and life-member of the American Society of Military Comptrollers, a member of the Transportation Research Forum, the Royal Statistical Society, of London, the Sons of the American Revolution, the Christian Church Club, and the Sigma XI and Phi Gamma Delta fraternities, and a recipient of the Imperial Cross of St. Nicholas. Colonel Osborne is survived by a daughter, Mrs. Phyllis O. Whitten, of Annandale, Va., two sisters, and three grandsons. Notes expressing the sympathy of the Class have been sent to the families of these two good classmates.

New addresses: Frederick A. Dale, 20 Forest Rd., Asheville, N.C., 28803; Kirk McFarlin, Box 367, Short Hills, N.J., 07078; Charles E. Woodlock, 170 Hillside Ave., Waterbury, Ct., 06710.—**Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Ct. 06119

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In next month's column you will have the story of our annual class cocktail party and dinner here on Alumni Day, June 4 at The M.I.T. Faculty Club. It's always been a good show.

Maurice Brandt's widow, Eleanor, wrote us a touching note wishing us a splendid get together at our June party for our 58th! . . . **Alice Anderson** is still tripping around and finished her winter cruise at Lauderdale.

Then, Margaret Runels, Lowell, Mass. cannot be at the Class party because she will be on her first European trip at that time. Good for her. At this writing we are all looking forward to the pleasure of seeing **Mary Plummer Rice** at our annual party. Helen wrote that **Boots Malone** has been having some serious trouble. We all feel deeply concerned for them both. They returned from Florida late in April and are settled at their lovely place in Chester, Vt. To quote Helen, "These golden years are not what they are cracked up to be." And, I thoroughly agree with her.

Henry Daley wrote: "While in Allentown, Pa., recently I had the pleasure of calling on **Bill Harbaugh** who resides in one of the Allentown suburbs. I hadn't seen him in over 15 years but the intervening years have treated him kindly and he looks hale and hearty. We had business relations for many years when he was with the Lehigh Portland Cement Co., of Allentown." . . . **Ray Gladding** sends regards to old classmates and says he is in good health and taking it easy. . . . From Indian Rocks, Fla., **John Homan** wrote to **Ben Neal**, "Our life here has not changed much in the 16 years we have been here, because it is on a much reduced scale from what it was in Massachusetts. We enjoy it, however. Golf is my main effort, but as I only started to play after being retired two years, you know it is no good for quality, only good for exercise." A Lockport, N.Y. paper, in a review of 50 years ago in that city, praised Ben Neal for his work at that time (1923) as Chairman of the Salvation Army Advisory Board. . . . **Ray Stringfield** in L.A. certainly has had an exciting time.

"We hate to admit it, but in a week or two it is going to be 58 years since M.I.T. let us loose. Of course young guys like you don't want to admit it, but I'm afraid it is beginning to show up on me," (and on many of us, Ray).

"It looks like my sins caught up with me this year. I'd been putting off an operation, wanting to get my wife, Margaret's, estate settled, and finally let them operate for a cataract on my left eye, and before I got the patch off, let my daughter Dorothy take me up to my cabin at Desert Hot Springs for the weekend, hoping to relax for a couple of days. Darned if I didn't fold up with a temperature of 104. They had to throw me in Desert Hospital in Palm Springs. I know I haven't nearly all my pep back yet. I've stopped doing any work for either of my two corporations, but the attorneys still keep trying to get me to check up on tire accident cases.

"My other daughter, Margaret, who is living with me since my wife, Margaret died, has a nice house at Lake Arrowhead that she bought when her husband died four years ago. We sneak up there for weekends and summer. Will probably spend some time this summer up there, and some at my sister-in-law's cabin at Sunset Beach, so guess I'm pretty lucky. My son, Bob, is visiting his daughter, Phyllis, in Djakarta, Indonesia."

"Best regards to you and Fran, and am glad you have more pep than I have at present. Don't think they can get rid of me yet, however, so maybe will catch up with you again."

Here endeth another season of the column. All the best to all you classmates and your families for a pleasant and enjoyable summer.—**Azel W. Mack**, Secretary, Apt. 26-A, 100 Memorial Dr., Cambridge, Mass. 02142

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Now that the 57th Reunion is over, all we have to do is to look forward to the 58th at the same delightful location with wonderful food and incomparable companions at the Chatham Bars Inn in Chatham, Cape Cod. A full account of this year's reunion activities will be given in the first issue of the *Review* this fall. . . . The Research Corporation's **Joseph Warren Baker** Fellowship in Engineering for 1973 has been awarded to Peter W. Huber, a graduate student at Tech. Joe Barker is very happy that the fellowship has been returned to Tech and that Tech "has attracted this type of man again."

We asked our good president, **Ralph Fletcher**, to let us have a word or two about what he had been doing besides working, and here's what he said: "Sibyl and I spent Easter holidays in Detroit with my daughter and five of her six children. . . . I had a nice visit with **Cy Guething** over the phone. He said he was very busy sitting in the garden having a drink, something he ordinarily doesn't do at 11:00 in the morning. He and Gypsy are very well. They are sorry that they will be unable to make the Reunion as they are not coming East this summer. You can imagine what I told him about that situation." . . . He said they contacted **Phil Baker** who was in good spirits and that his attendance at the Reunion was a matter of health. Then: "Sibyl and I are building a new house with the help of a very fine architect and a general contractor. The net result of this is that in spite of a completion bond that guaranteed the delivery of the house on December 6, 1972, we are now hoping for occupancy by Labor Day. As far as I am concerned, I am involved, business and personal, with planning boards and zoning commissions in over a dozen communities, not to mention ecologists galore" and also what he referred to as something like environmentalists and various and assorted do-gooders.

A telephone call some time later from **Cy Guething** pleased us with his cheerful voice and imparted the news that he and Gyps were not even going down in Maine this summer. . . . From **George Maverick** we had this word from Charlottesville, Va.: "The battle of two old people against the jungle has ended in the usual way. We couldn't fight the 250 acres with no help any longer. So we've sold our beloved Shepherd's Hill Farm and very well, I might add. Now in the 80th year of our lives and the 56th year of our marriage we are moving to a nice 10th floor apartment near the University of Virginia. There'll be time to rest and time to travel." . . . Nothing much has changed for **Nat Warshaw** of Randolph, he says, as he puts in three hours every day in the office. "In the afternoon," he writes: "I try to walk four to five miles weather permitting. I hope other classmates, if they possibly can, will also walk (not run) all they can! It is my observation that as you age, foot trouble can get you down. Once that happens you're almost out. So let's keep walking, is this old man's philosophy." . . . A letter from the **Dan Comiskeys** of Needham notes that Dan became involved last fall in the "Council on Aging" program for transportation for the elderly in Needham. This provides bus transportation (gratis) for about 100 persons, one day a week, for their needs in shopping, errands, appointments and for other trips. The cost is underwritten by a local merchant, very generously not limited to his store alone. Also a program five days a week provides two meals a day (at a cost of two dollars per day) for the 'shut-ins'—called 'Meals on Wheels' which is being developed in many states." . . . Gladys and **Francis Stern** had a good winter in Palm Springs but with coldish weather and a most unusual six-and-a-half inches of rain. "There was, however, a recompense, for the desert was covered with a variety and mass of wild flowers such as has not been seen in 30 years." Says Francis: "Palm Springs boasts of a very active museum. Its scope is not only pictures and sculpture, but also nature subjects and frequent film evenings of travel as well as art." As for sports: "I think you know from our past games together of the excellence of my own game. I wonder, however, if you realize I have improved so much that I no longer have a handicap but am a 'scratch' golfer. This means that when I come in, the pro looks over my card and scratches out all scores over five. As a result on a good day I end up with perhaps 20 or 25 for 18 holes." Unusual, what? Francis got back to Connecticut in time to go down to Pennsylvania for the opening of the trout season. Says: "This made 50 odd years of my trout fishing on the Brodheads stream on opening day."

Charlie Crosier of Rocky Hill, Conn., is participating in a Conservation Trust "which is seeking the preservation of large areas of flood plain lands adjoining the Connecticut River in this area, for agricultural and other nature-oriented uses. This together with various church activities keeps me quite fully occupied." . . . The **Art Shueys** had such a wonderful time on the Eclipse '72 expedition, they expect to be on *S.S. Canberra* for Eclipse '73. . . . **Allen Giles** writes that he and Mertie continue to spend summers at Clinton, Conn., on Long Island Sound and winters in Melrose. And like most of us now, the news of his family "centers mostly on the children and grandchildren. "His son Allen, Jr., is now completing his dissertation for a doctorate of music at Columbia and daughter, Dorothy, is working on her doctorate in classics at Harvard. . . . **Bob Kallejian** feels that one big mistake he made in his youth was going way out to California after he got married, for he has been unable to take part in any of the '16 doings in Cambridge or down on Cape Cod. . . . **Dick Berger** in Stamford who for years headed "Cancer Prevention" notes that he is trying to make our world a little better living space through the prevention of disease.

We regret to report the death of **Howard Hands** in Clearwater where he and Alice have been living since his retirement in Wellesley 12 years ago. He was in electric power sales. He was one of the six 16ers originally from Lowell and was your Secretary's electrical lab partner at Tech. At retirement he was an electrical engineer for the New England Electrical Service Company of Westboro, Mass. . . . We also regret to report the death of **George Hale** of Golden, Colo. For 38 years he was in Canada with Shawinigan Water and Power Co., whose subsidiaries operated calcium carbide and chemical plants. In the 50th Class history he said, "My most enjoyable kick came in 1940 when I was asked to assist in the design of a calcium carbide plant for an agent of the Ministry of Supply of Great Britain." As for "extracurricular activities", said George: "My wife and I greatly enjoyed fishing in the somewhat rugged parts of Quebec." (and Francis Stern please note) "the square-tail brook trout have migrated to the lakes. They are peppy, pan-size and prefer a wet fly. Now I am living in a little house slightly removed from the homestead but on the farm of my younger daughter and her husband and four grandchildren, 8 to 14. It is an amazing and frightening country."

And we also regret to report the death of Captain **Harold Larner** in the U.S. Naval Hospital Long Beach, Calif., on April 21. As his brother, Herbert, M.I.T. '18, kindly wrote us, Harold was an Instructor in the Department of Naval Architecture at Tech before joining the navy in World War I, where he had a long and distinguished career. "Among his numerous citations was one he received while serving with the U.S. Asiatic Fleet in 1938. His performance as officer-in-charge of salvage operations of the U.S.S. *Panay* at Shanghai, China, drew nationwide attention and was one of the highlights of his career." Thanks to his brother, we had a copy of the citation at the Reunion in June.

So now, take care and do have a pleasant and restful summer. Wherever you go, send a card or note to one of your easy-to-satisfy Secretaries!—**Harold F. Dodge**, Secretary, 96 Briarcliff Rd., Mountain Lakes, N.J. 07046; **Leonard Stone**, Assistant Secretary, 34-16 85th St., Jackson Heights, N.Y. 11372

Enos Curtin, '17

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Enos Curtin was honored on April 12 by being made Honorary Chairman of the Board of the National Society for the Prevention of Blindness. At the same time he was given the Mason Huntington Bigelow Award recently established "to honor a nonmedical person, organization or agency for outstanding contribution to prevention of blindness." Enos, "an investment banker, has served as a member of the Society since 1957. He held the office of President from 1959-1967 and was elected Chairman of the Board in 1967. His service as Chairman of the Finance and Financial Committees and as a member of numerous administrative committees has provided invaluable guidance. He is a board member of the American Foundation for the Blind, the New York Lighthouse, St. Barnabus Hospital, and a life trustee member of the American Field Services. His business affiliations include Madison Square Garden Corp., N.Y. Rangers, Inc., New York Knickerbockers Inc., American Economic Foundation, Eastern Utilities Associates, and Fall River Electric Lighting Co." Congratulations, Enie.

On May 14 **Al Lunn** hosted a very pleasant lunch at the Harvard Club for **Penn Brooks** in town from some Maine fishing, **Ray Stevens** recently returned from Florida, and **Stan Dunning.** It had been some time since the four had compared notes, activities, offspring, running a condominium, maintaining 200 head of Herefords, etcetera. Inquiries for classmates and references to and of other alumni with anecdotes came thick and fast. It was a good session.

Via Ray Brooks and also Penn Brooks there is interesting word of **Tom Ryan** in Ferguson, Mo.; he still carries on his sales business and is having an interesting experience which I doubt any other '17er is having, bringing up a 17-year-old boy, "the youngest of our five. The long hair, rock music, etc., etc., one has to learn to live with. He is a good kid, though, and we trust it will soon be over." . . . **Dick Catlett** comments, "My eyes are pretty bad, my wounded leg hurts from time to time, and my hearing is less than perfect but I am enjoying life."

In April the Dunnings, visiting in New Jersey, had an interesting two-hour call

on **Ray Brooks**. After his extensive surgery of last year he is on a restricted diet but looks and acts well. Asked if he would attend Alumni Day, Ray pointed out tentative dates involving the 50th anniversary of the airmail service, appearance at the Air Force Academy, and one at Salt Lake City. To this he commented," I simply cannot do all of it." The result is that he has decided to miss Alumni Day for the first time in years. . . . A call on the **Ray Blanchard**s revealed that they have sold their spacious home and will move this summer to an apartment in Malden. Ray gets to bank meetings often and Evelyn's eyes are improving from surgery. . . . The **Ed Paynes** are "back from a delightful six months junket in Europe and are catching up on things." . . . **George Henderson** has a new address, 2021 Hession Rd., Charlottesville, Va., 22903

If you haven't marked your calendar for Northfield Inn to arrive October 10 for two days you ought to do it now. Our reservations there are firm and the indications are that there will be a good Reunion turnout. Further information will be sent to you later.

Regretfully the death of **Frank S. Carson** is noted. He died June 7, 1971 at Ann Arbor, Mich.

Editor's Note: we would like to apologize for an error in last month's column. The Reunion was stated as being the 75th instead of the 57th.—**Stanley C. Dunning,** Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St., New York,

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Your Secretary is very happy to report that the Seltzers finally completed their interrupted one-day trip of a year ago to Europe—this time with success. Vienna and Zurich retain their old world charm and dignity despite the touches of modernity in the form of compact cars, mini skirts and neon lights (plus high rise buildings on the outskirts). Yugoslavia was cruder with its stark mountains yet beautiful with its Riviera on the Adriatic, full of lush semi-tropical vegetation along its spectacular coastline.

We are grateful to **Len Levine** for a most interesting letter from **Georgius Cannon**. In all the years since we graduated I have read with great interest the reports sent in by the men in our Class.

"I am still practicing architecture. Through the years my work has been residential, although I have done four or five churches also. But the last nine years in addition to houses, I have done several million dollars worth of work for the Little America Motels in Wyoming and here in Salt Lake City. I have had a wonderful life with excellent health, and have always thought it terrific to be alive. From 1925 to 1953 I lived in California. Until 1930 I was in Wallace Neff's office as Office Manager.

"After the depression I started my own practice which continued until 1953 when my wife died of cancer and I returned to Salt Lake City where I had always had about a third of my practice, even though I lived in California.

After coming back to Salt Lake City I was Chairman of the M.I.T. Educational Council for 12 years or so, and was made an Honorary Secretary of M.I.T.

A few years ago I was pleased to be made a Fellow of the American Institute of Architects and a Fellow of the Utah Heritage Foundation, and I am also listed in *Who's Who in America*.

"I have one daughter. She and her husband, a clinical psychologist live in Pasadena, Calif. I have two grandsons and a granddaughter. At 81 I am still in active practice. My family has been well represented at M.I.T. Three of my older brothers graduated from M.I.T. before I did. In the last few years two nephews have graduated from M.I.T. and another nephew did graduate work there.

"Last spring, when I thought I might retire and had let my work slack off for a few months, I went back to school at the University, taking a course in Dickens. I was glad that my mind was still clear enough for me to get an "A" in the course.

"It would please me if members of our class passing through Salt Lake City would let me know. In the years I have been out of school, only two of the Alumni have called on me here, Joe Clarkson in the early 20's and Willard C. Brown who has been here twice during the years. Thanks for writing me. It was the spark I needed."

Again thanks to Len Levine for this autobiography from **Henry Stephens**. "Dear Len, I hereby promise to come to the 60th Reunion, providing you will promise to come to my 120th Birthday Party 43 years hence. A long, happy and fruitful life is my wish for each and every one of my classmates. The vigor shown in your handwriting indicates that you too have learned how to retain your youthful zest. I am a good health addict interested in converting others in attaining a painless, tireless ageless body. After graduation from M.I.T. I entered the Steel Business and became Chief Metallurgical Engineer for one of the large steel companies. Business got slack and I became Chief Mining Engineer for the Lake Superior Metals Co., in Manitoba. Water flooded us at depth, so then I became Field Engineer in charge of Food Packing and Processing for the Hazel Atlas Glass Co.

"Business brought me to California to help a customer establish an orange juice packing plant. I developed processes for packing pure orange juice so that it would retain its natural fresh flavor. Designed Process equipment, built plants, and operated them for a ten-year period. During this interval I became President and General Manager of three different companies.

"In 1939 war clouds arose on the horizon so I went to work as a tool designer with Douglas Aircraft on the DC-3. After a few months I transferred to Vultex Aircraft where I led 50 designers in large production of the B.T. trainer. I became Aeronautical Design Engineer at Nashville for landing-gear operation on the dive bomber. Then I led a large group of aeronautical designers at Curtis Wright Columbus, Oh., on Hell Diver for ding wing jobs. At North Hollywood I designed components for the Pzu submarine destroyer airplane. After this I joined a group of competent engineers to form Aircraft and Tool Engineers, of which I became Chief Engineer and President.

"War business collapsed so we entered the building construction field. I became a licensed general building contractor and tile subcontractor in California. After 10 years of this I resigned. Then I worked as Design Engineer for North American Aviation in the Design of Mammoth TurboDumps for the Big Boosters and solved many interesting design problems for 3½ years.

"At Jet Propulsion Laboratories at California Institute of Technology I helped Jerry and Art Grant to design prototypes of space engines. This design work was transferred to Space Technology Laboratories now T.R.W. where I made the actual conceptual designs for the Lunar Excursion descent module and a whole family of test equipment to make certain this engine would function with assurance in space. Our concept which could stop and start any number of times and adjust its thrust in the unbelievable range of 20/1 was the most successful and dependable design produced to date in the entire space effort. I worked eleven and one-half years at T.R.W. and one and one-half years at S.P.L.

"Space work has been in the doldrums for the past two years. And I have enjoyed relaxing in Hawaii and stirring up projects for improving the local scene. I was elected President of the Board of Directors of Seaside Towers, a 126 apartment complex. In May I plan to return to California. I still have the urge to do things but my wife likes our present program of two swims daily in the ocean, two hours exercise at Ft. DeBussy and all the clubs and entertainment, fresh fruit and fish available here.

"I have two sons in California and some grandchildren besides a sister. My health is good—no operations ever and no sickness for many many years, no aches or pains or disabilities—I wish the same to you and all the rest of my classmates. Aloha."

My most faithful correspondent from California always manages to come out of any lethargy as you will note from the following. It is always stimulating to hear from **John Abrams**—I only wish I could include his free hand illustrations in the Class Notes you read. "Dear Max, no dottering retirement for me: I still can express regret that a trip East constitutes a luxury I can't indulge in while pursuing domestic and "better-government" matters here. (Brick Durham and I went ice fishing down the Cape 60 years ago—what a change I'll bet!). I'm winding up my 6' high cedar fence.

My lawns, mountain brook and garden all take time. Also my 'Cape Cod' house needs a coat of white paint. I have my battle with the City of L.A. ("drying up" Owens Valley). The five supervisors (of Imyo Co., pop. 17,000, area *10,000* sq. miles) our Assemblyman and the 5 small newspapers all contrive to knock me down. Like a Class Secretary all one gets is high praise and blandishment. But the reward is still—at 79 plus—in *not* growing old by deserting ideals.

"You asked once what a four-wheel-

John Abrams, '18, as what he calls, "a solemn-faced old sport dressed up like a mod-boy instead of the usual O.D. pants and laborer's shirt."

drive vehicle was: we war-Class boys knew them as heavy-duty, off-highway trucks. In World War II they came out as 'jeeps' and later International Harvester 'Scout'. I drive my Scout alone every year to Montana—my wife Evelyn, 21 years my junior, used to take it, but helps with yard work instead. Have a happy time!" . . .

We are very happy indeed—all of us—to congratulate Stella and **Al Grossman** who celebrated their golden wedding anniversary on June 7.

Words cannot adequately express my sorrow which I know you all share with me in reporting the passing of **Ed Rossman** on May 8. He was a most loyal son of M.I.T. and a faithful member of our Class. He endeared himself to us with his warm and kindly interest in us and in what we were doing. He achieved much in the automotive industry with many patents to his credit. His hobbies were varied—but in particular, he collected minerals—and fashioned them into attractive jewelry. As time went on we felt closer and closer to him—and there is a wrench in our hearts at his going. To his devoted Dorothy goes our deepest sympathy.

Stuart Boyd reports that he is now wearing a heart Pacemaker. He is unable to make our 55th but wishes to be remembered to all. . . . **Albert Walker** plays golf several times per week. He sings lead in the choir of the Central Presbyterian Church of Summit, N.J.—both he and the congregation enjoy it immensely. He celebrated his 54th wedding anniversary April 5. Congratulations and many happy returns of the day. . . . **Walter Biggar** reports his new address—67 Hadley Rd., Burlington, Vt., 05401 and Colonel **A. G. MacAlister**, 110 Woodland Ave., Haddonfield, N.J. 08033.—**Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard I. Levine**, 519 Washington St., Brookline, Mass. 02146

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Edmund Adams writes that he is enjoying some 12 years of retirement after 45 years service with Gulf States Utilities Co. He lives at 2484 Louisiana Ave., Beaumont, Texas 77702. . . . **Morton A. Smith** writes "Rather limited—have to stay put to keep house and care for my wife who has been an invalid several years. We have been married 47 years. Still do radio servicing although I sold the business ten years ago. Have seen a lot of changes in radio in 50 years operation." . . . **Louis T. Grayson** writes "Now that I am retired I find that I am just as busy as formerly. The difference is the almost total absence of tension. Of course there are so many interesting and educational non-curricular activities available here in Washington that one need never feel bored. At any rate, what with travel and other things I have no intention of ossifying."

A letter from **Don Way** said as follows: **Bill Langille** called me on the telephone April 27. He needs to confirm reservations at Chatham Bars Inn for our 55th Reunion. We agreed to make the reservation with exact date to be given later and commit us for an attendance of approximately 70 persons. I also want to thank you for the luncheon at Delray Beach, Fla., for Barbara and I. We both enjoyed seeing you both and also the luncheon place with the view of the waterway."

Kenneth A. Wright passed away on March 14, 1973 in Vicksburg, Miss., after a long illness. The Vicksburg *Evening Post* carried the following news; He was born in 1895, educated at Chauncey Hall and M.I.T. where he was a member of the Delta Upsilon fraternity. He was a second lieutenant in the Gas Warfare Division in World War I, a member of the Trinity Episcopal Church, Vicksburg and a former Rotarian. Before his retirement to Vicksburg in 1960, he was Vice President of Johnson Control Co., of Milwaukee, Wisc., with his headquarters in Chicago. Prior to that his home was in Cincinnati, Oh., for some 20 years. The Wrights bought and restored Anchuca, antebellum home and opened it to the public. He is survived by his wife, a native Vicksburger, a son from Chicago and two grandchildren.

Dean Webster has written about the development of a gift fund for M.I.T. to serve as a scholarship fund for our 55th gift to the Institute. I am sure the Class will back up this endeavor. Word was received from the Alumni Association of the death of Major General **Edmund W. Hill** at Belgrade Lakes, Maine 04918.

Will Langille's first notice of our 55th went out in May and the Reunion will begin Friday May 31, 1974 and Sunday June 2 at Chatham Bars Inn at Chatham, Mass., on Cape Cod. A later note from him gave the following "yes" for those planning to attend—**Francis A. Weiskittel**, **Dean Webster**, **Paul D. Sheeline**, **Leighton B. Smith**, **George Michelson**, **E. R. Smoley**, **Don Way**, **Will Langille**. Send your "yes" to Will Langille.

Dean Webster writes in May regarding the 55th Reunion gift for our Class. The Class will hear further on this regard from the committee.

Ben Bristol was on the list of those attending the last meeting of the Alumni Advisory Council of M.I.T. Alumni Association held in the Sloan Building in the Faculty Club.

Your Secretary plans on attending Alumni Day at M.I.T., June 4. Then a trip to Europe and on return about six weeks in Canada. Best to the Class for a fine summer.—**E. R. Smoley**, Secretary, 50 East Rd., Delray Beach, Fla. 33444

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A report on those attending the 25th Annual Fiesta in Mexico includes those intrepid stalwarts of our Class, **George Des Marais** and **Albert** "Count" **Dumas** accompanied by the charming and vivacious Evangeline. From what we hear, this was a truly gala occasion. A welcome note from **Ted Bossert** conveys the information that he has had a busy but rewarding time since his retirement in 1962. He has been spending three days a week as Curator of Botanical Portraits at the Hunt Institute, Carnegie Mellon University in Pittsburgh, a volunteer labor of love. Ted was instrumental in compiling a book listing the complete collection including pertinent biographies.

One of our well known and distinguished classmates has dropped from the ranks. **Dave Fiske** of Normandie Rd., Dover, Mass., died recently. A noted physicist, Dave's work made an important contribution to the success of U.S. space missions. He was active in the Army Laboratories in Natick, aiding in the design of space suits and space vehicle power units. He conducted special research on solar energy, holding a patent on a solar pump. Dave was awarded a doctorate in industrial engineering from Columbia University in 1941. After graduation he taught at the University before being appointed food consultant at the War Department. He was a member of the Economics Cooperation Administration Mission to Greece before joining the Natick Laboratories. A big name in the refrigeration field, he was the author of several papers on quick-freezing and the thermodynamics of refrigeration. He leaves his wife, Anna, a son and a daughter.

Through the courtesy of his widow we have information about the death of **William Nelson** of 360 Golden Oak Dr., Portola Valley, Calif. Bill graduated from U.S. Naval Academy before obtaining his M.S. with us. He advanced to Captain in the navy and was engaged in naval construction in World War I, became General Inspector of Naval Aircraft, Chief Engineer of the Naval Aircraft Factory and General Representative of the Bureau of Aeronautics, retiring in 1945 after which he was made Assistant to the President of Gar Wood Industries, then President of A.C.F. Brill Motors Co., of Philadelphia, Division Manager of Hall, Scott, Inc., President of T. G. Brill, Chairman of the Board Teleregister Corp., and Vice Chairman of Dubois Chemical, Inc. He was a director of many important corporations including W. R. Grace Co., Nelson Knitting Works, Altowil Corp., Alson Industries. He was a member of the U.S. Naval Institute and author of *Sea Plane Design and Airplane Lofting*. He leaves his wife, Faye, a son and a

daughter. The Class mourns the loss of these two illustrious men of achievement.—**Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

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As this is written, the Senate Watergate hearings have started and after four days it's hard to drag oneself away from the television tube to write Class Notes.

Walter J. Hamburger, the youngest member of the Class of 1921, continues to receive honors. His latest is the Distinguished Alumnus Award from the Polytechnic Institute of Brooklyn "given in recognition of Dr. Hamburger's outstanding contributions to his profession, to industry, to science and to society." After getting his B.S. in 1921 and M.S. in 1941 at M.I.T., Walt earned a Ph.D. at Brooklyn Poly in 1948. He has lectured at M.I.T. and Simmons College, served as a consultant to many governmental, military and industrial organizations, and is the retired Chairman and C.E.O. of Fabric Research Laboratories of Dedham, Mass. Classmates will remember him as Cleopatra, the leading lady of Tech Show 1920. Congratulations!

We reported early this year that **John W. Barriger, III** had left Boston and his "broom closet" on Tremont St., to go back to St. Louis. Now it turns out he got involved in consulting assignments (railroad operations?) just as he was about to leave, but will probably head westward in June. "Look for me on Alumni Day," said John (to be continued).

A clipping from *The Coast Star* (Manasquan, N.J.) recently received, tells of the founding of a historical society in the South Monmouth area which will concern itself with the collection and preservation of historical facts and objects. The organization meeting was under the direction of Secretary Emeritus **Carole A. Clarke** as temporary chairman. . . . A last minute change in plans resulted in Anne's accompanying **Wally Adams** on his trip during May to Israel, Greece and Italy. Wally and Anne have a joint passport and a new law requires that both people named on the passport travel together unless the second name is officially deleted. A nice long letter from Athens described their trip in some detail. A local Israeli guide gave them a walking tour around Old Jerusalem, but Wally said he acted his age and climbed the steep places by taxi. "Both we and our guide kept quoting from the Bible—on the spot—which made it come alive." Security was very tight and hand bags and cameras were examined frequently when they entered old and new shrines. The Israeli army was very much in evidence, particularly during their 25th Anniversary Parade. Quoting Wally, "Thirty thousand people came into Jerusalem to celebrate. Even out in the country where we were, it was like our fourth of July—every picnic spot was filled."

A welcome letter from B. Alden Thresher, '20, brought pleasant memories of the days when your scribe was an Honorary Secretary and "Bat" was Director of Admissions at M.I.T. "Bat" is now living in Cocoa Beach, Fla., in apartment towers, overlooking the ocean, the Indian River and the Cape Kennedy Space Center. His letter brought sad news of the death of Colonel **Harold O. Bixby** who was living in the same apartment towers. Harold got degrees from both M.I.T. and Harvard, the latter, a master of science in 1929. He made the army his career, starting as a private in the short-lived S.A.T.C. and ending as a Colonel in the Signal Corps. He worked on many electronic developments used during World War II, was in charge of communications in the Caribbean, served in Washington as Chief of Personnel for the Signal Corps, and after the surrender of Japan entered with General MacArthur's first contingent and was placed in charge of communications for the northern half of Japan. After retirement he was a consultant for the World Bank and supervised projects in Ethiopia, Paraguay and India. The sympathy of the Class is extended to his wife and family. Much of the above information was gleaned by "Bat" Thresher from random conversations with Harold Bixby.

A Treasurer's report has been received from **A. Royal Wood** indicating that our class treasury is in good condition. Roy confirmed reports of a fine 25th Fiesta in Mexico and mentioned as stand outs, the party at Nish Cornish's house and the trip to the pyramids. They returned to their winter vacation spot in Sarasota, Fla., for a few weeks after the Fiesta. . . . **Marion** and **George Chutter** spent Easter with their son Roger's family in Grand Rapids. Upon their return to Cape Cod, the phone rang within minutes after arrival and **Bob Miller** announced himself, having arrived in West Chatham a day or two earlier. George writes that the Thursday luncheon club of Chutter, Miller, **Whitney Wetherell** and **Don McGuire** has now resumed its active bull sessions for the summer. As usual, George is up to his neck in activities: nominating committees, church boards. "I'm looking forward to the day we can retire from retirement," says George.

Your Secretary's wife took part in a couple of events during April, outside her usual way of life. The first was an all day genealogical symposium in Indianapolis sponsored by the Indiana Historical Society. Subject: "Church Records—Baptist, Lutheran, Presbyterian—as Research Tools." Betty held forth on Baptist records on which she is knowledgeable. The two other participants were gentlemen of the cloth. She said the whole weekend which included attending Quaker Meeting was a pleasure, "the likes of which you never did see." Later in the month, we drove to old Sturbridge Village, Mass., where we met our son, a member of the Village's Board of Overseers. Together they planted a Roxbury Russet apple tree in a newly established preservation orchard. Betty says it's the first time she has ever ridden on an ancestor's coat tails. The ancestor was the Joseph Warren who developed the Roxbury Russet. Your Secretary applauded at the proper points and was among the guests entertained at lunch at the Village Tavern. Bonus: Betty received a complimentary membership in the Worcester County Horticultural Society.—**Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla., 33580; **Samuel E. Lunden**, Assistant Secretary for California, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

There is a passage in Shakespeare regarding "sweet sorrow" which defines our feelings as we leave on our annual Buffalo Chamber of Commerce Trade Mission in May. We must cancel plans for the marvelous time with our classmates at the Institute June 3 and 4. This depressed feeling will be overcome by the receptions to be given for us in Vienna, Kiev, Moscow, Yalta, Leningrad, Helsinki and Stockholm. It's unfortunate to be away from Buffalo during this beautiful May golfing season. . . . Perhaps those of you attending Alumni Day will write notes regarding the occasion in Cambridge for use in the October/November *Review*. We will then bring you up to date on happenings in and about the Kremlin.

Elmer E. Sanborn of Atlanta wrote regarding the pleasant M.I.T. Alumni sponsored flight to Copenhagen in March. He was the only member of our Class in the group but met many new friends from other classes. He found this type of travel to be most worthwhile. . . . **William E. Cooper** of Albany has adopted a new afternoon golfing and gardening schedule while working at an industrial supply firm in the mornings. He thanks his many classmates who made our 50th Reunion so enjoyable and successful. . . . **Karl E. Schoenherr** of Washington, D.C. retired from government service in 1963. He has remained professionally active by designing propellors for merchant ships. He says that at the age of 80 he is planning to completely retire because of the special complications of a propellor for single-screw ships now absorbing 25000 HP. No wonder he calls them "quite a headache"! . . . We were delighted to hear that **Florence W. Stiles** will return to Monhegan for two weeks in July with reduced luggage "via taxis, Greyhound and the good old mail boat". To Florence, life is still interesting and challenging. She says even old age is interesting! We will not believe that Florence will ever grow old!

We received a short but interesting review by Edward Weeks from the May issue of *Atlantic Monthly* on "Trolley to the Moon"—An Autobiography by **Eric Hodgins**. He says that Eric died before he could finish what would have been his best book, which carries him only as far as the mid-30s recording his friendship and admiration for Henry Luce.

We also extend the sympathy of the Class to the family of **Paul M. Kellogg** who passed away April 26th in Peabody, Mass.

President Parke received a letter from **Fred Blackall**'s son, F. Steel Blackall the 3rd saying that Fred's grandson, Frederick S. Blackall, IV (Rick) will be entering the Institute this fall in pursuit of

a master's in metallurgy. This certainly would have pleased grandpa Fred. Rick will receive his Batchelor's in metallurgy from Lafayette this June. . . . **Mac McCurdy** had a visit from world travelers Katherine and **Dale Spoor** as they breezed around the U.S. Mac and his Catherine have arrived back in Seattle from their desert home and are planning on a good summer's cruising on their craft *Blue Peter.* Dale and Katherine, the team known as Dalenka, spent a couple of weeks at our Prexy Parke's condominium home in Venice, Fla., while Parke and Madeline were in Dover, Mass., selling their country place. They move to Venice on June 21 permanently where they welcome all the "snowbirds" fleeing the northern winters.

Don Carpenter and Parke are hosting a dinner at the Ritz on the Thursday of Alumni Weekend for the three Class of 1922 Professors, John Wulff, Paul Gray and Roy Lamson as well as Margaret L. A. Macvicar, the first recipient of the Class of 1922 Career Development Award in the development of excellence in teaching.

The sympathy of our Class is extended to the family of **C. Ford Blanchard** whose last address was Pt. Pleasant Beach, N.J. . . . We are sorry to hear from Mrs. Gill of Lakewood, N.J., that **Thomas H. Gill** passed away on April 17. He was most helpful and enjoyable company at our Alumni Day gatherings. . . . Here's hoping you all enjoy Alumni Day '73 with balmy breezes coming across the Charles River and moonlight shimmering on its water—you lucky people! Next notes will be from Moscow so study the Russian Alphabet.—**Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203

23

As this is written, the great 50th Reunion is just two weeks away but a matter of history to you who read it. With 139 persons registered as coming we wonder how many more last minute decisions will be reached. We have a few newsworthy notes to relate however, so here goes. From **R. C. Kleinberger**, call sign W20N, we learn that he has frequently "worked" **Howard Russell**, K4IAZ, but has not heard to date **Rod Goetchius**, W7HHC.

Through the Alumni Association we learn that **Laurence E. Barstow** retired in September 1972 from Lear-Siegler Division of Burroughs Corp. He reports the dismaying fact of a fire in his Kalamazoo apartment in which he lost nearly all of his possessions! . . . **F. O. Almquist** writes that he retired from the Connecticut State Department of Health in 1964 and that he returned in 1965 to work as a part-time consultant until 1967. Since then he has worked almost full time as a consultant with Camp, Dresser and McKee in Boston and later with Henry Souther Engineering Co., as a Sanitary Engineer. . . . **F. Robert Robinson** also writes that he was confined to the hospital with pneumonia last winter. We trust that you are fully recovered now Robbie and it appears that you are from the excellent typing of your letter of last February! (Miss) **R. M. Katapetoff Cobb** wrote that she was unable to attend the Reunion, " . . . because ten days ago I went across the street to pitch a few to a little leaguer, fell, and hurt more than my --- year old dignity." She goes on to recall that some time ago on the open lot between Walker and the main buildings—"the Research Lab of Applied Chemistry put me in at shortstop, a position for which I was not physically designed. Every hit ball went right between my shins. When the bell rang and I stopped playing and looked up there were 3000 men looking on and not one of them had jeered! Have fun!"

Also a brief letter from **Atherton Hastings** explaining his inability to attend the Reunion, "Regards and best wishes to my classmates." . . . Another letter from **Ben F. Powell** tells us that "about a month ago I sustained a serious injury from a fall and have never recovered from this and other ailments, so I am sure that the trip to Boston and the routine of the graduation would be beyond my physical ability." We are sorry that you couldn't make it, Ben.

Proceeding now to the sad duties of reporting deaths, we learn of the passing of **Clarence W. Chaisson** of Auburndale, Mass., on April 29 of this year. After graduating with our Class he spent most of his life in Newton where he founded the Capital Engineering Co. . . . Also, **Lew L. Harr** of Murrell's Inlet, S.C. died on May 11 of this year, as reported by Ed Schmitz, in his letter to Mrs. Harr.

Rowland J. Robinson of St. Louis, Mo., passed away on November 3, 1972. Finally in a letter to Herb Hayden written by the son of **Jnanendra M. Sil**, we learn of the latter's passing in April of this year in New Delhi, India. His son tells us his father often spoke of M.I.T. and his feeling that there "was no greater institution in the world for learning." He goes on to say that his father was a very accomplished violinist and had a very inventive turn of mind, as well. His major effort in this field was the development of his "Intensity Rain gauge" which was named after him and used by the meteorological departments of many countries. "My mother and I would like to convey our very best wishes and all success to your M.I.T. Reunion."—**Thomas E. Rounds**, Secretary-Treasurer, 4 Deer Hill Dr., Danbury, Conn. 06810

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The genial spirit of writing this issue's Notes has degenerated considerably because of incoming news. The task is more like writing an obituary column. To the bereaved and loved ones of the departed, I extend, for the Class its deep sympathy.

John F. (Jack) **Hennessy**, our Fiftieth Gift Chairman, passed away April 24, 1973 at his Caribbean home in Nassau. Jack had not been well for a year, although devoting some time to his business. His firm was nationally known for the design of the mechanical and electrical systems in many prominent buildings, including the United Nations, Lincoln Center, Madison Square Garden and several of the newer Rockefeller Center structures. In World War II, he was a Colonel in the air force. He has been the Chairman of many educational, church and charitable Boards and building committees. Jack also had Honorary Doctor of Engineering and Doctor of Laws degrees from two colleges. One of his sons, John F., Jr., '51, is a member of his firm, Syska and Hennessy in New York City.

Alfred L. Chardon died of diabetes on October 7, 1972, in South Orange, N.J., the note seems to indicate. Al received his S.M. in chemical engineering. He is survived by his mother and first cousin, **Ellis O. (Ollie) Jones** of Chevy Chase, Md. . . . **Frederick W. Fulle** passed on April 9, 1973 in North Harpswell, Maine, at the age of 74. He was a graduate of Williams College, was in the armed forces and vice president of Sylvania Electric of Canada until he retired in 1962. . . . We have been advised by the widow of **Wheeler G. Lovell** of his death on November 28, 1971, in Bloomfield Hills, Mich. He was a 1922 Harvard graduate, and as a chemical engineer spent most of his life with General Motors in Fuel Research, as director, then becoming a consultant. Numerous patents relating to automotive fuels were granted to him and he authored technical articles on the subject.

One of our Class telethons revealed the death of Col. **Walter C. Thee** on December 23, 1972 in Columbia, S.C. He may have been the oldest member of the Class, born in 1893, graduated from the University of Missouri in 1917. Although his degrees were in mechanical engineering, he entered the army in 1917, spent time in the C.A.C. in France and Panama and in 1922 moved to the Quartermaster Corps, becoming a Lieutenant Colonel and officer in charge of special projects in 1949.

Bill Correale, my monitor probe in New York City, sends a good snapshot of him and his two Brooklyn Polytechnic Institute cohorts giving Mayor Lindsay "the works." It consists of a sizeable report on a series of fire tests on high-rise office buildings. The conclusions were convincing, as the Mayor has already signed building code amendments. Jack Hennessy, also, had continually stressed the urgency of fire protection methods in high-rise buildings. . . . A second member, **Julian A. Joffe**, has attained prominence in the cultural field with his book, "Studies in the History of Civilization." The reviewer calls it, "one of the best original works in this field of the year. Its underlying thesis is that man neither is, nor ever was, a sapient creature. He supports this thesis with a remarkable display of academic erudition." Joff came to us in his junior year with a B.S. from the College of the City of New York, received his S.B. degree in Engineering Administration and gained a M.A. in Sociology, later. He now does his thinking at Rainbow Lake in New York.

Dr. **Frederick E. Terman**, Vice President and Provost Emeritus of Stanford University, received his Sc.D. in electrical engineering with us. In 1920 at Stanford, he was awarded an A.B. in chemical engineering and in 1922 an E.E. From 1925, he progressed through the ranks, becoming Dean, Stanford School of Engineer-

Arthur F. Merewether (right) receives 1972 Edgar S. Gorrell Award from Paul R. Ignatius, President of Air Transport Association. Portrait in background is Colonel Gorrell, founding President of the A.T.A., for whom the award recognizing contributions to the safety and reliability of air transportation was named.

ing in 1945. Harvard granted him an Honorary Sc.D. in 1945 as the Director of the Harvard University Radio Research Laboratory for three years developing counter measures against radar use by the enemy.

This briefing partially explains why Fred will be honored at Stanford by the construction of a $9.2 million complex to be named the Frederick E. Terman Engineering Center. Principal donors are two of Fred's former students, one of whom is William R. Hewlett, '36, who credits him for much of the inspiration and encouragement to form the Hewlett-Packard Co. The donors jointly stated that Professor Terman has made immense contributions to Stanford, to higher education and to the engineering profession, and that it is largely through his untiring efforts that the University's School of Engineering today ranks among the best in the world. If I may inject a personal note here—Fred was a voracious bridge player at our Theta Xi House—and what a partner! The Charles Goren of that era.

Your Class officers are happy to report that **Ed Hanley** has agreed to assume the duties of 50th Reunion Gift Chairman. His address: E. J. Hanley, Chairman, Finance Committee, Allegheny Ludlum Industries, Inc., Oliver Building, Pittsburgh, Pa. 15222.—**Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146

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Arthur F. Merewether was presented the 1972 Gorrell Award of the Air Transport Association by the President of the A.T.A., Paul R. Ignatius, in Washington on April 18, 1973. The Gorrell Award is presented "for outstanding contributions toward improvement of weather analysis, weather forecasting or the dispatching of airline aircraft, thereby enhancing the reliability and safety of air transport."

Art Merewether was chief of the U.S. Army Air Corps weather service at the beginning of World War II and received the award in recognition of his pioneering work in developing and using computer flight planning for the American Airlines System where he served as manager—weather services, 1946-1966. As early as 1934-35 and serving as an Army Air Corps pilot he flew daily observation atmospheric sounding flights out of Logan Airport, Boston.

Thomas M. Lowe is now Senior Vice President of Lowe Engineers of Atlanta, Ga. . . . **George E. Mason** of Keene, N.H., is "still alive and waiting for '75—50th Reunion." . . . **Anthony Tsongas** of Jackson Heights, N.Y., spent last fall traveling in Portugal, Spain and France. From Madrid he traveled by train to Bordeaux and Paris where he found that prices were very high. I sometimes think that if I were able to collect from all our class members' records of trips they have taken I should be able to compose a travel guide to almost anywhere. This leads up to the point that my wife and I will be off again in September. This time our trip will take us to Norway, Sweden and Denmark including a boat trip to the North Cape. This should make the third time that we have been North of the Arctic Circle and like crossing the Equator or the Atlantic in the early days of flying should entitle us to membership in some group. We shall return via England to visit friends there.

Arthur E. Bysshe of Mamaroneck, N.Y. passed on in September, 1972, also **J. Marshall Osborne** of Torrance, Calif., April 3, 1972.—**E. Willard Gardiner**, Secretary, 53 Foster St., Cambridge, Mass.

26

Your Secretary cannot remember writing Notes at night—sounds like poor planning. Actually the planning includes getting the sailboat overboard in the morning and there were a few problems today. At high tide the mooring had disappeared and there is little point to launching with no place to tie up. The mooring appeared again at low tide and this evening we have been busy making a longer pennant (the rope that connects to the anchor chain) and that's why we are burning the midnight oil. Fortunately some of you have sent along some Alumni Fund envelopes to help out. **Al Entwhistle**, our motel and restaurant-owning classmate says, "Tell the boys to help an old classmate and patronize Howard Johnson's motor lodges when you travel." . . . And **"Bud" Wilbur** has commented "My principal activity as senior lecturer in Civil Engineering is that of running the M.I.T. Ottauquechee Project in Woodstock, Vt., in cooperation with the Ottauquechee Regional Planning and Development Commission."

Your Secretary never publishes Notes of thanks from classmates even though they are deeply appreciated. In the following instance we are publishing a classmate's note: "After many years of helpful and devoted service *from* our Class Secretary, I think it is high time *to send him* best wishes and thanks from *all of us* of '26.—J.Q. (Jim) duPont." As those of you know, who read these Notes, Jim du Pont died suddenly five weeks after writing this deeply moving note.

Jim Killian recently wrote us about the establishment of a new fellowship in the graduate school as follows, "The M.I.T. Graduate School has established a graduate fellowship in honor of the late Dr. **Marron W. Fort**, a distinguished chemist who was the first black American to receive a doctor's degree from M.I.T. The Fort Fellowships, the first of which will be awarded for the 1973-74 academic year, will provide full tuition and living expenses for one academic year for an outstanding M.I.T. minority senior who will pursue full-time graduate study at M.I.T." Those of us who knew Marron Fort recall him as a soft spoken, gentle man with an extremely keen mind. The fellowship is a fitting honor. It is interesting to note that his widow, Mrs. Alice Fort heads the English Department at Woodrow Wilson High School in Washington, D.C. and his son, Dr. Marron W. Fort, Jr., is a professor at the University of New Hampshire.

Don Cunningham recently received a letter from **Frank Schreiner's** wife's niece which told of Frank's sudden death from an acute ulcer condition. Frank was one of a core who never missed a reunion and our 50th will not be quite the same without him.

Argo Landau who attended his first reunion at our 45th has written that his wife Edna, who showed the exquisite slides at our 45th, went around the world again last year but Argo has given up trying to keep up with her (he gave up 20 years). However, he goes along in the winter for the trip to Hawaii! . . . Finally a note from **George Makaroff** in New York says, "Have visited Asheville, N.C.—glorious! And Miami—good for the last mile. But for the present I am sticking it

out a little longer in the Fun City."

A notice just received from the Alumni Office reports the death of Major General **Edward J. McGrew.** "Dan" had been living in Fayetteville, N.C., since retiring. We have no further information.

We expect that some of you will be in the vicinity of Pigeon Cove this summer and if you can catch me when I'm not out on the sailboat, it would be great to see you. In any event have a nice summer and Cheerio until fall.—**George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

I hope my recent mail is not an accurate picture of the Class of 1927. Judging from the mail, the Class must be sitting on its collective back porch idly waiting for the Grim Reaper.

Things used to be different. Just ten years ago: **Bob deLucca** received the Engineer of the Year award for 1962 from the Professional Engineers of Oregon. . . . **Al Buffum** was appointed Director of Manufacturing of Miles Laboratories. . . . **Frank Marcucella** was elected a director of Lawrence Memorial Hospital in Medford, Mass. . . . **Clarence Wynd** joined Eastman Kodak's Executive Committee. . . . **Fred Willcutt** and his 14-year-old son had just completed a trip down the intercoastal Waterway in an outboard runabout from Washington to Miami—some 1250 miles. . . . **Frank Cahill** won a first prize of $140,000 in the Irish Sweepstakes. . . . And **Fritz Hooven** was appointed Director of the Research Planning Office of Ford Motor Co.

A mere five years ago: **Bill Payne's** Payne and Co., was acquired by Mead Corp. . . . **Nat Cohn** was awarded the Lamme Medal by the I.E.E. and was selected as Engineer of the Year in the Delaware Valley. **Andy Anderson** retired as Vice President of Monroe International. . . . **George Darling** was the first American to receive the Supreme Award of the Japan Medical Association.

Apparently the only way to elicit mail is to print a misstatement in the Notes. In the May issue I reported an address change for Dr. **John Vinti** (received from the Alumni Office) from Allston, Mass., to Brussels, Belgium. Dr. Vinti is still in Allston. He writes: "Last summer I took a scientific trip to Germany, France, Belgium, and England, giving one lecture each in Germany and Belgium. The postcard I sent from Belgium must have misled someone. I am still a member of the Measurement Systems Laboratory at M.I.T. in the Aero-Astro Department and a lecturer in celestial mechanics at M.I.T.

Sam Auchincloss has retired from A.M.P. Incorporated but still works for the company about one week a month as consultant and retains his position on the Board of Directors. The rest of his time he spends in Florida "boating, fishing, sunning, and socializing." . . . **Amos T. Ackerman** reports that he retired as a U.S. Army colonel after completion of 30 years' service in the Corps of Engineers, including service in Europe in World War II.

Word has just been received of the death of **Marvin H. Dixon** in January, 1972 and of **Virgil Quadri** in June, 1972. I have received no details.

A note from **Sid Badger** says he is still active as a consulting metallurgical engineer in Woodland Hills, Calif.—**Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

Never again will we underestimate the spirit of '28! Now, just four days before our 45 year Class Reunion, we have a registration list of about 160—nearly double that expected. Bald Peak Colony Club will be bulging! However, even with the loss of five rooms (yes, one of the club cottages just burned down) we do have a place for everyone to sleep. It will be a big party and, judging from the many notes coming in, the enthusiasm will be high. We will give a full report of it all in the next issue of Class Notes. The completed Class Directory forms that were mailed back to us make very interesting reading. Here from this source are some random news items: Following his retirement as President of Stora Kopparberg Corp., in U.S. and Canadian operations in 1971, **Harold Bialkowsky** set up a project to build a retirement home in the Columbia River Gorge near Bonneville in the heart of the Cascades. Now he keeps busy with woodworking, landscaping and checking the local streams for trout and steelhead. . . . **Wally Bissell,** reporting that he is "retired (but thickly retreaded)" is busy as Grand Secretary of Royal Arch Masons of Connecticut. His other interests include coin collecting, photography and fraternity activities. He is drum major and plays tenor sax in the Shrine Band. He and Louise have been married since September 12, 1928. Their 13 year old granddaughter is already a concert pianist, having played with the Grosse Pointe (Mich.) Symphony, Grand Rapids (Mich.) Symphony and (over TV) with Windsor, Ontario Symphony. She has won the right to enter a contest to play with Detroit Symphony. Wally and Louise are immensely proud of her.

Al Gracia reports 44 years of married life with a score of two children and seven grandchildren. He says: "We spend three months in Maine each summer, three months in the Virgin Islands each winter and six months at home fixing up the things that go wrong while we have been away!" . . . Wasting no words, **Dave Haynes** writes simply that his interests at York Beach, Maine are in civic affairs and lobstering. . . . **Ev Lester** is building a new home in Williamsburg, Va. Following this project the Lesters plan to do a lot of traveling, both domestic and foreign. . . . From Tokyo, Japan **Shikao Ikehara** writes that he is Professor at the Tokyo Electrical Engineering College and lecturer at two others. He says: "For a graduate course I teach mathematics in the tradition of Norbert Wiener, and cybernetics for the junior and senior students in the Musashino Arts University. I am interested in mathematics but have little time for research. I enjoy walking, picture taking, and visiting art galleries in Ginza, Tokyo." The Ikeharas have four children and three grandchildren. . . . **Jay Monier** expressed disappointment in not getting to the Reunion. He had planned to attend but had to be hospitalized for a serious hernia repair job which will now keep him inactive for about three months. . . . Writing for **Carl Myers**, wife Frances says: "We remember the 40th Reunion with great pleasure and are sorry that Carl's illness prevents us from attending the 45th." . . . **Ed Pitt,** who retired as President of Sherman Div., Regis Paper Co., in 1971, has now started a consulting business to develop new foam plastics for the manufacture of cushion packaging. He is setting up a first manufacturing plant in Massachusetts and a second plant in Chicago this year with two more to follow next year. Though working hard, Ed reports feeling younger than ever. He and wife Barbara are living in Boca Raton, Fla., and invite all 28ers to call them when passing that way.

Ethel (Mrs. **Carl J.**) **Bernhardt** is active in many clubs relating to her interests in volunteer work, gardening, flower arrangement and antiques. Two years ago she drove over 2500 miles from Hamburg, N.Y. to Sun City, Ariz., and to Florida. She plans to be at the Reunion and will join Florence Jope, Mary Nichols, and Frannie Donovan for the automobile trip from Boston. . . . In a note to **Carl Feldman, Des Shipley** explained that he would be unable to attend the Reunion because his son would be graduating from law school on June 3. He says: "I missed the 40th and was sure I would be at this one but the distance between Washington, D.C. and New Hampshire precludes my even trying. Give my regards to everyone and hoist one for me."

Envelope panels from the Alumni Fund Office give us the following bits of news: **John Houpis** wrote, "Greetings from Greece. Though alone now (I lost my wife a year ago last December) I am still going. I enjoy good health—I guess it is the climate and good living. I would be happy to meet any classmates coming through this part of the world. Being so far away, I don't think I can make it to the 45th." In an appended note John says his son, Basil, will be graduating from Fairleigh-Dickinson University this year. This could possibly bring him to the U.S. and the Reunion. . . . **Jack Rouleau, Karl Otte**, and **Newt Foster** all had the same message: planning to be at Bald Peak with their wives. . . . **Hal Curtis** said: "Have been retired since 1966 after 38 years with A.T. and T. and the Bell Telephone Labs. I have two daughters (both Radcliffe) and sons-in-law (both Harvard). One of the latter is a physicist at the Institute for Advanced Study at Princeton, the other an attorney. I am enjoying retirement tremendously. Have had three long stays in Europe. My hobbies are reading and the Curtis genealogy."

With deep regret we must report the tragic death of **Richard D. Wilhite** and his wife Mary on January 29, 1973. They were on an Egyptian commercial airline flight enroute from Cairo to Cyprus. All 37 aboard were killed when the plane crashed in mountains 12 miles short of

the landing field.—**Walter J. Smith**, Secretary, 209 Waverly St., Arlington, Mass. 02174

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Like the National Presidential elections, plans for our 45th Reunion, which is now in sight, was formulated almost five years ago, under the direction of **Frank Mead** and his Executive Board. Reservations were made and confirmed at the Wianno Club (the Cape). Unfortunately, the M.I.T. faculty and administration have felt it necessary to hold Commencement and Alumni Day Activities a week earlier than in the past. Since the Wianno Club operates on a seasonal basis, they could not accommodate us a week earlier. To resolve this problem, Frank Mead called a special general meeting on April 24, 1973 at the M.I.T. Faculty Club. The following alternatives were presented for consideration: (a) To keep our reservation at the Wianno Club, (which would be a week earlier than Alumni Day) (b) To have a winter reunion at some place like Bermuda, Florida etc. (c) To have our Reunion at Chatham Bars Inn (the Cape) to coincide with Alumni Day. The concensus favored the third choice, so it will be at Chatham Bars Inn, Thursday May 30 to Sunday June 2 followed by the usual Alumni Weekend activities. **Mal Hubbard**, who was not present, was the unanimous choice for General Chairman of our 45th Reunion. Heads of other Reunion Committees are as follows: alphabetically: **Karnig S. Dinjian**, Publicity; **Jerry Gardner**, Treasurer, **Eleanor Horwitz**, Secretary; **Ted Malstrom**, Hotel Reservations; **Joe Speyer**, Gifts.

Frank Mead and **Eric Bianci** will share the responsibility of arranging for sports, fishing and golf. Those who attended the meeting were: **Bill Baumrunker**, Helen and **Karnig Dinjian**, Fran and **Paul Donahue**, Joan and **Wally Gale**, Mary and **Jerry Gardner**; **Eleanor Horwitz**, Florence and **Ted Malstrom**, Mary and **Frank Mead**, Ruth and **Joe Speyer**, and Ethel and **Dave Wilson**. So! Mark your calendars for the date (May 30-June 2) our great 45th Reunion.

Ruth (Davies) Van Wagener announces her marriage to Mr. Raymond G. Haun which took place on March 19, 1973. Ruth's husband died about two years ago. They will reside at 1386 Plaza Pacifica, Santa Barbara, Calif. 93108. . . . **Clifford M. Wallis**, Professor Emeritus of University of Missouri was the recipient of an honor award for distinguished service in engineering bestowed by the university. . . . **Lloyd W. Vickery** has retired from Continental Oil Co., as Manager of its engineering department. He does some consulting work and is managing a 2800-acre ranch in "Kaw Country" in Oklahoma. "Lots of fun and work," he says. . . . **Hunter Rouse** writes, "We are just back from Fiji, New Zealand and Australia where I lectured for three months. With luck, we will be back at Karlsruhe, Germany, my old post-graduate haunt for a working summer, then back here (University of Iowa) for the last year of tenure. Two new grandchildren since last year; our oldest son has three sons (in Paris for the year) and our daughter has three daughters. Segregation is not over yet! Thanks for your annual birthday greetings; in return my annual commendation for keeping the 1929 column so full."

Sidney G. Albert is still active in his company, Albert Pipe Supply Co., as President. His oldest son Arthur E. is an Associate Professor of Statistics at Boston University. He has published two books on advanced statistics. His youngest son, Stephen J. is a composer of modern classical music whose works have been played by the Chicago and Philadelphia Symphony Orchestras in 1972. Sidney's hobbies are golf and traveling. . . . **Richard E. Bolton**, Montreal, Canada, has retired since December 1970 from his private practice of architecture after a distinguished career. After he left M.I.T. in '29, he spent a few years in Europe. He returned to Canada and went in private practice in 1933, married in 1935, '41 to '46 joined the Royal Canadian Navy, then back to private practice in 1946. He became a Fellow, Royal Architectural Institute of Canada in 1956, Academician of the Royal Canadian Academy of Arts in 1968, Chancellor, College of Fellows, R.A.I.C., 1970 to 1973. His life work has been designing buildings and small town layouts. He has designed buildings for the armed forces, hospitals, universities, schools and an embassy in Bonn. "Now that we have more time," he continues, "we travel a bit and enjoy visiting our grandchildren. I still mess around with sailboats. Each summer, I usually spend a few days in Kennebunkport, Maine, visit a cousin in England one in Virginia. My chief complaint is that there still isn't enough time to do all the things I have lined up to do."

Richard T. Hoffman is still going strong and has set his goal for retirement in 1975. . . . **Paul Gill** was hospitalized from December 3, 1972 to April 16. He has been back in circulation after a few weeks of convalescing in a nursing home.

I regret to announce the death of **Thomas E. Dodson** of Franklin, Maine on May 11, 1973.

N. Vaughn Ballou, Dublin, N.H., writes, "Paying intolerable taxes and feeding the birds." . . . Professor **John Happel, Jr.**, writes, "Many thanks for your birthday greetings. My wife and I took the children to Gaspovilla Inn near Fort Myers, Fla., over the Christmas holidays. I hope we'll make the 45th Reunion." . . . **Charles B. Bacon** is still active in his business (mechanical contracting). Two of his sons are associated with him.

Winfield H. Bearce writes, "Thanks for the birthday card which arrived on an auspicious occasion as I have just joined the Club (Social Security and Medicare). We have spent some time in Naples, Fla., this winter and hope to come back next year. My official retirement date was May 1, 1973, but I was forced to take some sick leave to recover from surgery last year. It is hoped that time will restore some of my old 'zing'. Regards to all '29ers." . . . **Charles T. Allen** of Cambridge, Mass., writes, "I was at M.I.T. only during 1925-1926 academic year, as a special student. I am not a graduate of M.I.T. Many thanks for the nice birthday card with the seal of the Institute, though I don't deserve it." . . . **Sadik L. Baroudi** of Hama, Syria, has sent a note which reads, "I am under contract with Major Project Administration of the Syrian Government as a Water Supply and Irrigation engineer. My eldest son, Walid is studying for his master's at the University of California in Sacramento. My second son, Basam will be graduating this summer from the University of Damascus in Civil Engineering. My oldest daughter will graduate with an M.D. this June and the younger children are still in grade school. My wife and I are in good health, thank the Lord. How we wish we could visit M.I.T. and old Boston. But that is just a dream—our Syrian currency and our standard of living makes it hard to realize such a dream. My best regards to all our classmates."

Albert Harris of Brookline, Mass., is still active in his self-employed business as a C.P.A. "I still have a few accounts" he says, "that I take care of and I am also a tax consultant at the H. and R. Block with headquarters in Boston. I just celebrated my 75th birthday. I am a bit older than most of you. In June, 1971, I received an Associate Degree in Arts from Harvard and at present, I am working towards my B.A. degree from Harvard."

Though **Bion H. Francis** is theoretically retired, he seems as busy as ever. He is a Contributing Editor for *Business Insurance*. He has written about 60 articles and a book in the past few years. His latest is a "Business Idea Workshop." He and his wife went to Greece this spring for three weeks. . . . **Robert S. Riley** writes that his first marriage in 1931 ended in divorce in 1965, having four children and ten grandchildren. He remarried in 1967, so that his family status stands as of now: eight children and 18 grandchildren. He was officially retired May 1971 from Engineered Sinterings and Plastics, Inc.", but he still works three days a week for the same company. "I still like to go North (for skiing) instead of South." He continues, "I went to the Austrian Tyrol for two weeks last winter. My children are spread all over the country, so I like to travel and see them."

I received a letter from **Howard G. Pankratz** who was on a business trip to Taipei, Taiwan. "Business is booming here," he says "I am here for two days visiting friends and trying to do a little business with a synthetic milk product known as 'Farmer's Daughter.' There are no cows on Taiwan—milk must be imported. Margaret has had both eyes operated on for cataracts. We have moved from our big house which we purchased in 1963 to a place called the 'Meadows'—an adult mobile home park with all kinds of luxuries, such as swimming pools, sauna etc. We have a three bedroom, two bath, 24 foot by 61 foot mobile home and we are very happy to be here."—**Karnig S. Dinjian**, Secretary, 6 Plaice Cove, Hampton, N.H. 03842

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Notices of retirement continue to come in as an increasing number of our class-

mates reach the traditional retirement age. . . . **Bill Lodge** retired last year as Vice President of C.B.S. Television Network in charge of Affiliate Relations. He has continued to act as a consultant to C.B.S., as well as to the Lamont Doherty Oceanographic Laboratory at Columbia University. The Lodges have built a home in St. Croix where they spend "6.1 months per year," but have kept their home in Hastings-on-Hudson for use during the summer months. . . . **Homer Davis** has retired from the Signal Corps. He thereafter joined the staff of Stanford University, where he is working in the field of conservation of energy. . . . **Alvah Perkins** retired from the Air Force some years ago. He reports that he is now on disability retirement, but is able to pursue several hobbies, the chief of which is scribe and toll collector for the Veterans Association of the 1880th Engineer Aviation Battalion, his W.W. II outfit. They have annual national or regional reunions. . . . **Harry Shaw** retired on January 1 as Assistant to the Vice President of the El Paso Works of Phelps Dodge Refining. Harry worked for American Smelting and Refining Corp., in Tacoma until 1940, at which time he joined the staff of the Braden Copper Co., a Chilean subsidiary of Kennecott, as smelter superintendent. In 1950 he became superintendent of Kennecott's refinery in Magna, Utah and in 1960 left Kennecott to join the Phelps Dodge staff.

Albert Wagar has retired as Manager of Industrial Engineering for Cluett Peabody and Co., in Troy, N.Y. He lists among his present activities "making toys for grandchildren." . . . **Sven Lindhard** has retired from F. L. Smidth and Co., where he was a cement chemist and special process engineer for the application, design and operation of rotary kilns. He mentions cooking and the baking of breads among his hobbies. He and his wife are now "enjoying a nice retired life, doing the things we want to do when we feel like it." . . . **Norman Dolloff** retired in February as Chairman of the Department of Geology at San Jose State College. He plans to travel and write. His travel plans include trips to New Zealand and Australia which he considers "sort of a geologists' paradises." . . . **Sig Linderoth** is Professor of Mechanical Engineering at Duke University and a Technical Consultant to the Duke Medical Center's hyperbaric research laboratory. He teaches mechanical design and ocean engineering. His specialty is the physiology of deep sea diving. In 1971 he took a six-months sabbatical leave during which he and Doris traveled through Europe and Israel, visiting all of the important research centers in Europe that do work on deep-sea-diving physiology. While in Sweden he had a family reunion with relatives that he had not seen in 50 years. Last year he and Doris attended an Underwater Physiology Symposium at Freeport, Grand Bahama Island and more recently he gave a paper at a Working Divers Symposium in New Orleans. He reports that the **Fred Dickermans**, on their way back to Florida from the 40th reunion, stopped in to see them. Also Alene and **Joe Harrington** stayed with the Linderoths in April while Joe gave a seminar at the Duke mechanical engineering department. The Linderoths have two married daughters, one of whom has the somewhat "off-beat" hobby of raising Arabian horses. . . .

Lauri Lindell retired from the Boston General Services Administration in 1971, but has continued to practice architecture from his home in Lexington, designing new homes. The Lindells have two daughters: Elizabeth, who is married and has three children; and Linda, who is a nurse at Emerson Hospital in Concord. . . . **Max Wheildon** of Norton Co., was the recipient of the Worcester Engineering Society's 1973 Scientific Achievement Award. As previously reported, Max is the inventor of the ROKIDE process for spraying ceramic coatings on devices that are to be used at high temperatures. More than a million rocket nozzles, including those of the X-15 experimental rocket planes, have been protected by this process. . . . **Morris Shaffer** was recently appointed the new Dean of the Graduate School of Biomedical Sciences of the College of Medicine and Dentistry of New Jersey in Newark. Morris received his doctoral degree from Oxford University in England where he was a Rhodes Scholar. He moves to his new position from the Tulane University School of Medicine in New Orleans where he was Chairman of the Microbiology Department.

Guests at the 25th annual Fiesta of the M.I.T. Club of Mexico City in March included Mary and **Charley Abbott** and Etta and **John Moriaty.**

We have at hand a note that **Robert Sealy, Jr.**, died on October 9, 1972. Unfortunately no details are available.

Changes of address: William B. Lodge, P. O. Box 1805, Christiansted, St. Croix, U.S.V.I. 00820; Francis J. Noonan, 58 Estes St., Lynn, Mass. 01902; Charles A. Smith, Jr., 88 Old Colony Rd., Hyannis, Mass. 02601—**Gordon K. Lister**, Secretary, 530 Fifth Ave., N.Y., N.Y. 10036

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William Nixon tells me he retired from Tennessee Valley Authority, Knoxville, Tenn., in July 1972 after 35 years with the agency. He was chief materials engineer and responsible for technical advice on the selection of engineering materials and equipment for T.V.A. projects. . . . **Carrington Mason** writes that he enjoyed the Fiesta of the M.I.T. Club in Mexico City and the Mini Reunion of our Class. He was elected Engineer of the Year 1973 by Region IV Texas Society of Professional Engineers and the Engineers Council of Houston. . . . Congratulations to **Jim Fisk** on his election to the position of Chairman of the Board of Directors of Bell Labs. . . . **John Sherman** retired over a year ago and with his wife, Cris, took a two months trip through South America, including a visit in Chile with his son, John, and his family. . . . **C. N. Gilmore** writes that he was elected Fellow of A.I.Ch.E. in August 1972. Had a very pleasant conversation a few weeks ago by ham radio with my old friend, **John Hollywood.**

A recent publicity release tells of **Gordon Brown**'s appointment to Institute Professor and Dugald Caleb Jackson Professor of Electrical Engineering. An article in the *Wall Street Journal* mentions that **Jim Jamieson** Exxon's Chairman, warned a Japanese group in Tokyo against a proposal that oil-importing nations unite to confront exporters. . . . **Ed Goodman** reports that he is still with Sprague Electric at their Headquarters in North Adams, Mass., where he is Manager of Foreign Facilities Planning. . . . A note from **Willis Fleisher Jr.**, tells that he has been retired since September 1971 and is enjoying cruising in Florida waters with his wife, Mary, in their 33-foot cruiser. . . . **Dick Ashenden** says he enjoyed a new experience last summer house boating for a week on Rainy Lake on the Minnesota-Canada border. Word from Paul Semple tells of his retirement in 1969 and that his wife Irene has now joined him in retirement. Paul is Director of Western Oil and Minerals Corp., in Farmington, N.M., and he attends directors' meetings twice a year. . . . **Leon Fraikin** has been President of Belgian American Educational Foundation Inc. and is located at 420 Lexington Ave., N.Y., 10017, Room 2740. . . . **Bob McKenzie** is still enjoying retirement after 10 years with home maintenance, travel and some charity work keeping him busy.

With sorrow, I report the death of our following classmates: **Meyer P. White** on November 5, Herman Albert in January 1971, David Goodman on December 13, 1972 and Dr. Richard Huntington. Our deepest sympathy to their families.

George T. Bevan will retire from General Electric's Transportation Systems Business Division at Erie, Penn., on July 1, 1973 after working for 32 years. His latest assignment was as Manager of the Locomotive Application Engineering Division. During the 1950s he was assigned to the International Division and did considerable traveling in Latin America on locomotive matters. He was also assigned for a ten-year period with the A.L.C.O.-G.E. Division in Schenectady, N.Y.

After leaving the VI-A Course and the Boston elevated option in 1932 he worked for a short time for the Chicago Surface Lines, and in the late '30s went to work for the Denver, and Rio Grande Western in Denver, Colo., for several years. He and his wife Marie have a son and a daughter, both married and are living in the Finger Lakes region of up-state New York. After June 15 he plans to be in his new home on New York's Seneca Lake, where he plans to water ski with his three grandchildren and do some lake trout fishing and gardening. His new address is 955 East Lake Rd., Romulus, N.Y. 14541.—**Edward S. Worden,** Secretary, 35 Minute Man Hill, Westport, Conn. 06880

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Jim Harper gives your Secretary a helping hand with the following report of news in Maryland, Virginia and District of Columbia area. After a very successful military career, retiring with the rank of Colonel, Jim completed his government service at the Civil Service Commission.

Jim's account of recent class activities included these items; Captain **John W. King 3rd**, U.S.N. Ret., is remaining active as a stockbroker with Esterbrook and Co., in Alexandria, Va., and in his spare hobby time is paneling his basement, including a gleaming formica bar. His son Captain John W. King 4th, U.S.N., is carrying on the family tradition and is on duty at the Pentagon. . . . Colonel **Richard L. Morgan** is still busy working on army standardization matters at Fort Belvoir, Va. . . . **Robert W. West** has retired but continues to stay busy with church choir work and flamenco guitar lessons. . . . **Arthur D. Jewell** retired in 1972 from his position as Assistant Principal of McKinley High School Washington, D.C.

We have a belated report on the passing of **Ralph W. Crary** at Bethesda, Md., June 18, 1971.

Erwin D. Kreugel has retired after 30 years of government service with the Defense Supply Agency, Department of Defense and is finding his retirement time completely occupied, including model railroading. . . . **Dwight S. Ashley** recently retired from government service after spending 30 years with the Civil Service Commission and the Army Signal Corps and is now polishing up his golf game with the ultimate object of breaking 100 consistently. . . . Dr. **Howard M. Quigley** while retired from active work in the educational field for the deaf, which had included superintending schools for the deaf in Iowa and Kansas, continues to maintain his interest as an advisor of audio visual materials for the deaf. Howard and Mrs. Quigley have spent some of their leisure time traveling to Europe and Hawaii in the last few years. . . . Our thanks to Jim for such a fine report and we trust some of you other vice presidents will follow suit.

Hank Smith informs us that he is enjoying his fifth year of retirement in the best of health at Leisure Village, Lakewood, N.J. . . . Dr. **Jacob Millman** relates in a note that he will spend his sabbatical next year at the University of Tel Aviv in Israel. He has been named the Charles Batchelor of Electrical Engineering at Columbia University and has had his sixth textbook published, *Integrated Electronics, Analog and Digital Circuits and Systems*. . . . **F. Carlyle Roberts** advises in a recent note that he retired from the U.S. Public Service in 1970 and since retirement has been engaged in the development of a small ranch from completely undeveloped land in Patagonia, Ariz. Most of the work including a road, well, and water system together with a fence around the place has been the result of his own labors.—**John W. Flatley**, Secretary, 6652-32nd Street N.W., Washington, D.C. 20015

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As of April 29, we now start the first set of records since January; you all must know why! From one of our eminent, and very friendly ex-Presidents, **Dick Fossett**, we have a fine letter. Dick had an operation in November, and has recovered well as expected. While in the hospital, Charalee had a phone call from Ellis Littman's telethon gang. The Fossetts will, as of then, attend the 40th (as you read, now history) Dick retired from Procter and Gamble January 1972, and finds the leisure palatable. He has worked ten years with the M.I.T. educational council, in Orange County, and, so sees Francis Marchant, our man in Long Beach. Aside from this Council work, Dick and Charalee have done quite a lot of short trip skiing, in Yosemite, Aspen, and Sun Valley. They also took a short trip to Hawaii, accompanied by Dick's mother, 90, who insisted on climbing to the lip of the volcano Mauna Ulu. Wow! September last, the Fossetts flew to Norway, S.A.S. non stop Seattle to Bergen; saw the Greenland Icecap, the northern lights, and climbed a few mountains. They finished off this long trip with one more; all the coastal countries, Norway to Spain. Many thanks, Dick and Charalee.

From Penn State University comes a rather long press release concerning their now retired Professor of Speech, **Art Hungerford.** Art's nice letter, written after Christmas is another matter; though he is now established at Antioch College. His family is still located at State College, with Art doing some commuting. Art is Associate Director of Programs, the University without walls. The lovely Helen spent three weeks in Mexico in March ('72), and they both toured the British Isles for three weeks before Art took up his work at Antioch.

Now come three of the most acceptable Christmas letters; **Horace MacKechnie** and Prue as always, have been busy; Horace still with P.E.S.O. (see earlier columns). Dear little Prue, it seems, had herself a major operation in January '72. Art gives us more on nephew, Eliot Wigginsons' book, *Foxfire*. . . . Germain and **Jack Andrews** come through with their Christmas letter, always good. It is a family story; Daughter, Gail, was married in May; Jamie, Colorado daughter, teaching kindergarten, first and second grades; Son, John, now has a construction job in Vail, Colo.; Gwen still in Cambridge, at Harvard Extension summer school, and by now already has her degree. She works at Harvard as secretary. Valerie is now bent on earning a master's degree at Temple University, and works part time, also. Jack and Germain appear to be continuing their home activities, what with the Princeton Skating Club, concerts and repertory, Friends of the Art Museum, some skiing when available, Jack still at his church reading, and much more golf.

We love these season's greetings and can't decide who does best. Thanks so much, Golly, just dug up two more: Jeanette and **Werner Bachli**, and Marcia and **Red Payne**. You will recall that Werner has been mixed up in establishing a new plant for I.G.E. somewhere in the Orient. It appears that Australia might well be the final location of the new plant. However, while decisions are made, the Bachlis are established in Lenox, Mass., near the Pittsfield works, G.E. This is one of those that has to be either quoted or paraphrased. However, inasmuch as the Bachlis will have attended the 40th, maybe first-hand news will be better.

Busier than ever are Marcia and **Red Payne**; Daughter, Marcia, even with four children, attended summer school, and is now teaching. Children Duncan and France have returned from abroad and are living in a graduate students' apartment, and Dunc is striving for his master's in Stanford's graduate school of business administration. Son, Rob, has completed his master's at the University of South Carolina, and has only a thesis to go, for his Doctors. He is with the Environmental Protection Agency. The Paynes are travelers, having visited Tobago, Amsterdam at Tulip time, Barcelona, and along the south coast to Motril, thence inland to Granada. Then, they fished for the great Atlantic salmon in Iceland, brought plenty back, smoked and frozen, way south to Georgia. In November, they flew again, first to England, then to France for Marcia's sister-city program. Red, it appears, will retire for good January first, 1973; plans will no doubt come in later. Great stuff, Red and Marcia. We love it. . . . We are always glad to hear from Colonel **C. T. Newton**, who allows that the second retirement is by far the best. He is still a consultant, however. His travels, now, are tending towards the south, keeping in mind to where the next move might well take place. Thanks, Colonel.

I am somewhat ashamed to find a letter from **Cal Mohr**, dated late December; full of news. On a visit to Rochester, Cal really found out. . . . He saw **Bob Smith** and wife at an antique show; one of about 25 that they use for exhibition of primitive tools and furniture. It appears that the retirement work is both enjoyable and profitable. . . . **Walt Swanton** is busy with pollution equipment activities. He has two daughters living in or near Rochester. Something new on Red Payne; he is interested in the use of balloons in his special photography, probably of archeological sites, and maybe in the Near East. Golly, Red has to work to keep busy. . . . **Adam Sysko** will have retired as of January first, and is moving to Florida. Adam, see ye scribe's Florida address. It appears that **Dave Treadwell** is, or has been, very, very ill, but Cal had no further information. Cal talked with Mrs. **Dave Babcock** (Dave was out of town). Dave has been given a major development assignment by Eastman; also, Dave has charge of renovations at the old church where Cal attended and sang in the Choir, as a boy.

I must include what Cal has to say in his March letter. It seems that the Mohrs attended a concert by the M.I.T. Symphony Orchestra, in Chicago. **Dick Payzant** and his good wife were with the Mohrs. Other 1933 men who showed up, were **Bob Seyl**, **Gus Martin**, and **Harry Summer**, all with their wives. Dick Payzant allows that the DUSAF contract has been extended through another year, so Florida will have to wait for Dick for a while. Nothing to report from any of the others except that **Harry Summer's** son is to be married come June. Cal brings up a point that needs a bit of coverage. His information, just above, did not appear in the *Review*. The story: for the first time in many years, I have too much material for the February to June columns. I chose selectively, by my own

judgment, as something had to be left until later.

Golly, here is one from our own **Emmy Norris**, dated too far back to admit. Emmy took in a meeting of the M.I.T. Club of Western Maine, at Portland. The speaker was Dr. Murray Eden, of a group who are seeking to apply electrical engineering to medicine and biology. Emmy, it is my understanding that M.I.T. has been in "medicine" for some long time, though I have no information on when Dr. Eden's group got started. It seems that Emmy has been busy around the house; electrical fixtures, refinishing furniture etc. Although we have no news, he mentions five M.I.T. men living in Newcastle, including **Skee Burzynski**. He does not write me, either. Emmy gives us a great sales talk on historic Newcastle and Portsmouth. He needs visitors (address on request). Thanks, friend.

We have a Mobil Report, which has an article covering a speech made by our own Dr. **Dayton H. Clewell**, before the Swedish Museum of Science and Technology, on the predicted costs of automotive air pollution control. In substance, Dayt told the boys that the controls effective today add about $40 per car, and, that controls added since, will add close to $500 per car. I must find out why the Swedes needed this information. However, we better be respectful to this fella, as there is every likelihood that he will be Class President when you read this.

I have here a nice note from **Courtenay Marshall**, saying that he will attend the 40th, and he included a montage of his own home photos. . . . A report from the Mexico City M.I.T. Club Fiesta, 25th annual, in March, was attended by the following classmates; Mr. and Mrs. **William E. Baur**, Mr. and Mrs. **Edward M. Kimback**, Mr. and Mrs. **Ellis C. Littmann**, Mr. and Mrs. **Charles W. MacMillan**, and, a late arrival, **Clarence R. Westaway**, one of our Vice Presidents, and General Chairman of the 40th Reunion. From Baur we get the finest note expressing their thanks for our pushing this great event. They loved it, and, will appear at the 40th.

Many address changes have appeared since our last; Fred L. Brugger, Professor Forest P. Dexter, Jr., Leamon F. Donahue, D. Malcolm Fleming, Walter S. Galazzi, Ivan A. Getting, Joseph C. Gray, Ellis C. Littmann, Ivan Mankowich, Arthur T. Mason, Maxwell D. V. Millard, Richard C. Molloy, Frank A. Record, Robert P. Ripin, Richard A. Tutein, Robert P. Woods, Dana P. Currough, Monroe H. Kessler. Should anyone need any of these address changes, he has only to ask me via the mails, and, his request must be a part of a family story, suitable for printing.

As always, we are shocked and saddened to hear about the passing of any of our classmates. **Harry W. Gabar**, E.E., passed away in February, and, **Henry B. Kroger** passed on almost four years ago. Always, where too much time has not elapsed, your Secretary will get in touch with the widow in question, or if she is not available, then the nearest known survivor.

At the request of President Turner, we add a postscript; (written 18 days before the 40th. I quote "Ellis C. Littmann will make his 40th Fund report that we have achieved our goal better than 100 per cent. Seventy per cent of our active class members (plus many who did not finish with us), contributed to the Fund, and, 35 classmen who took advanced degrees in 1933, also contributed. Personally, this is a remarkable record. I will not list the officers elected, except that our new President will be **Dayton Clewell**, and **Ellis C. Littmann** will be our new Executive Vice President. The remaining officers will be reported in our September interim letter."

That is all for this time around, but, if there is enough material, I will write an interim letter, in September.—**Warren J. Henderson**, Secretary, Fort Rock Farm, Exeter, N.H. 03833

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Two notes have come in via the Alumni Fund: **Lewis B. Simon** writes: "Have become involved in local airport and environmental concerns and was appointed a member of the Aviation Advisory Committee for the County." **Wilton G. Hawes** says, "I was appointed as a member of the Education Council by President Killian 20 years ago and have been interviewing prospective M.I.T. students ever since." On February 28, Wilton retired from his position as Architect and Engineer Contact Representative for the Grand Rapids District of the Michigan Consolidated Gas Co. "My employment began March 21, 1955, so it will be almost 18 years. Future plans? Will play it by ear. Progeny—two daughters ages 22 and 27, married."

This note comes from **John Taplin** by way of Bob Forster's questionnaire: "I am Chairman of the Board of the Bellofram Corp. This company produces various kinds of automatic control units and also anti-pollution elements for vehicles. In addition I spend several days a week assisting the New York Blood Center/American Red Cross in the development of automated processes for the taking and processing of blood. I am looking forward to the time when these procedures will be installed throughout the country, since this will eliminate a lot of tedious work connected with the handling of human blood. I am looking forward to assisting the committee on our plans for the 40th Reunion so that all members of the Class will attend." This was written right after John and his wife returned from a most interesting and enjoyable trip to Italy—so interesting that they are looking forward to an early return.

We have word from **Henry B. Kimball**, who writes, "After years in Mountain Lakes, N.J., and St. Louis, Mo., I am shortly moving back to New England. Am Manager of the Lamp and Glass Machinery Division of Swanson-Erie Corp., with headquarters in Danvers, Mass. Needless to say, the prospect of returning to God's country is very exciting." Please call me, Henry, 899-7735 during the day so I can learn where an old friend from Swampscott days has landed.

Five 35ers were among the participants in the first annual M.I.T. Golf Championship, sponsored by the M.I.T Club of Boston at the Charles River Country Club on May 21: **Ned Collins**, **Al Johnson**, **Fran Muldowney**, **Art Marquardt** and **Allan Mowatt**. Both Leo Beckwith and **Bob Forster** were out of the city on business and couldn't make it. We had a great time and the weather held up for us. There is more detail about this affair elsewhere in the *Review*.

Leo Beckwith is the proud grandfather of a little girl born in early April "in rural North Carolina." Congratulations to Betty and Leo and the parents. . . . Frances and **Dexter Clough** went to Paris in May for the French Ophthalmological Society meeting with members of the New England Society. . . . **Dick Bailey** says lots of things have happened to him in the last year: "Got married to a lovely 45-year old widow with three beautiful daughters on December 31. Went to Puerto Rico. Had a great wedding and honeymoon. She teaches guidance in the Bristol High School. Bought a house back in Ridgefields which we have not moved into yet. Between the house, work, extracurricula activities and all these women I have a hard time keeping up with the world. So life is very interesting—life begins at 60! Hope to get to New England around the first of July." . . . **John Brosnahan** was "out of the country until May 31." Next month: WHERE? . . . **Ham Dow** reports that he and Edith entertained Verna and **Gerry Rich** at the Villages St. Patrick's Day dinner-dance. He is out to try to keep **Sid Grazi** from repeating a win on the President's Trophy in the 13th Annual Class Golf Tournament. (Along with 14 others).

I am sorry to have to report the loss of two more of our classmates: **Richard L. Moses** in Gloversville, N.Y. April 6, 1971 and **George H. Hunt** on April 10, 1973. I am sending our deepest sympathy to the two widows on behalf of our Class. **Les Brooks** wrote to me about George Hunt as follows: "He was one of a few fellows I chummed with during my four years at M.I.T. I believe he spent most of his career with Simplex in Cambridge working on high voltage and submarine cables. A few years ago Simplex moved to Berwick, Maine and George moved too. About a year later the company went under and George was out of a job." Subsequently George landed a job with a company in the Mid-West but was there only a few months when a heart attack felled him. The only address M.I.T. has for him is 12 Countryfield Circle, Kennebunk, Maine. If any of you have a later one we would like to learn of it.

The 13th Annual Class Golf Tournament is under way with a full flight of 16. If any of you prefer other than golf news in the next *Review*, you had better take pen in hand or dust off the typewriter right now.—**Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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The M.I.T. Club of Mexico City reports that Gladys and **Norm Copeland** attended the club's 25th Fiesta in March. Other

travelers include Betty and **Bob Hannam** who spent last Christmas in Christ Church, New Zealand after nearly a year in Australia. Prior to this extended trip "down under" Bob was Transportation Engineer with the California Public Utilities Commission in San Francisco. . . . **Larry Kanters** is still travelling, by company plane throughout the midwest, putting on road shows of seasonal merchandise for the franchise outlets of his firm, Gamble-Skogmo of Minneapolis. . . . **Bill Hewlett** (and David Packard) have been in the news several times. The founders of Hewlett-Packard have received the Founders Medal of the I.E.E.E. "for leadership in the development of electronic instruments, for creative management of an industrial activity, and for their unselfish public service." They are also the principal donors to the new Terman Engineering Center at Stanford University, the institution which Bill attended before coming to M.I.T. for graduate work.

When the Alumni Office sends notice of address changes it is sometimes hard to tell which changes represent a significant move. The following are obviously in this category: **Vincent Dobert** has moved from Florida to Columbus, Miss.; and **Robert Edwards** from Arlington to Harwichport, Mass. Coming to Massachusetts are (from Pennsylvania) **Frederick Story** to Scituate and (from California) **Bill Canning** to Hingham. Farther a field, **Frederick House** is with Badger in Antwerp, Belgium (Tavernierkaai 2 B-20000. . . . Dr. **Albert Klemka** has moved from Hudson, Ohio to Dover, N.H. and the **Russell Millers** from New Jersey to Fryeburg, Maine. . . . **John Stapler** has left Buffalo for Bernardsville, N.J. . . . Some of the rest of us stay put. With his contribution to the Alumni Fund **Rufus Isaacs** reports that he is *still* a professor of applied mathematics at Johns Hopkins.—**Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

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Earl Frazer is Secretary-Treasurer of the California Chapter of the American Institute of Planners. He wrote that, "Sacramento County adopted a new general plan prepared by our department containing urban service areas and anti-sprawl policies and which involved a year and a half of heated hearings and law suits." . . . **George Tapley** has been Secretary of the Sterling, Massachusetts Housing Authority for over four years. He celebrated his 71st Birthday on March 15, 1973. . . . **Bill Bergen** is still President of the North American Aerospace Group of Rockwell International. His apartment is located on the Marina del Rey area, next to the Pacific, and Bill writes that he gets a bang out of watching all the Southern California crews going up and down in front of his apartment. . . . **Phil Dreissgacker** attended the Olympics in Munich while on a family vacation. His oldest son, Dick, rowed in straight four for the U.S.A. His son has been rowing with Vesper in Philadelphia since graduating from Brown in '69. His younger son, Peter, graduates from Stanford this June. Phil writes that "the Olympic Games were a tremendous spectacle and highly motivating for those participating and associated with the games".

Nancy Klock is still working at the University of Hartford and has been doing a bit of traveling in the U.S.A., to Arizona and California. . . . **Bert Bennison** writes that, "a faculty appointment to F.S.U., adds the stimulation of graduate level seminars to the continuing challenges of leading a growing three county Health Department." . . . **Earl M. Fischer** has changed his address to P.O. Box 62, Rt. 3, Shawnee Mission, Kansas 66210. . . . **Bob Goldsmith** writes that he will not be able to attend Alumni Day as he was just up to the Institute to collect his son, Chris, whose classes stopped in May. . . . **Dick Young**, **Phil Peters** and **John Fellouris** called around the U.S.A., April 5, to remind some of the Class that we are trying to keep up the Class Gift momentum. Every pledge and contribution until our 40th Reunion will be credited to that big Reunion Gift total.

Martin Garrott's address has been changed to 100 NE 43rd St., Miami, Fla., 33137. . . . **Martin Deutsch**, Professor in the M.I.T. Physics Department and a noted experimental physicist, has been named Director of the M.I.T. Laboratory for Nuclear Science. He is best known for the discovery of Positronium. . . . **Albert C. Hall**, Assistant Secretary of Defense for Intelligence, was presented the Department of Defense Distinguished Public Service Medal by Secretary Melvin Laird at the Pentagon on January 3, 1973. He was recognized for his guidance and leadership in his recently established position for bringing the totality of the Department of Defense intelligence programs under a coherent and integrated management system.

Our Class was represented at the twenty fifth annual M.I.T. Fiesta in Mexico, March 15-17, 1973 by Alanson W. Chandler and his wife, Louise, along with Wells Coleman. **Art Zimmerman's** daughter just graduated from Hillsdale College and Art sent along a clipping in regards to the Keithley Instruments, Inc., receiving the Presidents "E" Award for excellence in exports which was presented at the 1973 Cleveland and the World Dinner. **Joe Keithley**, received the award which climaxed the World Trade Week celebration.—**Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester H. Klashman**, Assistant Secretary, P.O. Box 961, Peabody, Mass. 01960

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This is written well in advance of, and will be printed long after our most successful 35th Reunion at Stratton Mountain. As you are very well aware **Paul Black** did an outstanding job on arranging and running the Reunion.

We have some bits of news: **Bob Johnson** has been elected Advisory Director of New England Merchants Bank. Bob has been President and Chief Executive Officer of Arkwright-Boston Manufacturers Insurance Co., and Mutual Boiler and Machinery Insurance, Inc., for a number of years. . . . **Barney Oldfield** writes, "President, Searle Medidata Inc., Lexington, Mass., Board of Directors, International Health Evaluation Association, Secretary Association for the Advancement of Medical Instrumentation." . . . **Isaac Schwartz** writes that he is the father of three children, one married and pregnant. He is still working at Schwartz Lumber and he is enjoying himself. . . . **Bob Elliot** has retired from airline flying and continues to fly as a freelance pilot on charter, aerial mapping and miscellaneous flying jobs. He would like to hear from **Ed Usher**, **Henry Sieradski**, and any other members of the original M.I.T. Flying Club, where he learned to fly in 1936-37 at the Norwood Airport. He sends his very best wishes to all of them wherever they may be. . . . **Walter Johnson** left the consulting engineering field two years ago when he left Jackson and Moreland, Boston, for a position as Senior Mechanical Engineer, Plant Engineering Department, Digital Equipment Corp., with the home office at Maynard, Mass. The President of Digital Equipment Corp., is **Ken Olsen**, also a M.I.T. graduate. . . . **Dick Young** got practically a full-page ad in the *Boston Globe*, May 2 in connection with the annual stock holder meeting of Acushnet Co., as a matter of fact he was photographed smiling. This is probably because your Secretary just bought a set of Titleist irons which means that my handicap will probably go down. . . . **Clark Robinson** apologized for missing the Reunion because he and Rachel were in Saskatoon where he is working on the design of a new electron accelerator installation at the University of Saskatchewan. . . . Also a note from **Russell Coile** apologizing for not being able to make the Reunion. He will be in England for another year and asks any '38ers who might be in London within the next year to call him at 01-629-9222. . . . **Don McDonald** writes, "Unhappily, I find that it just won't be possible, for a number of reasons, for me to make the Reunion. Principal among these are the facts that I shall just at that time be trying to get around 150 final grades into the Registrar here and moving out of my rented house for the summer tenant, and Jeanie will be doing more or less the same thing at her elementary school in Washington."—**A. L. Bruneau, Jr.**, Secretary, Hurdman and Cranstoun, Penney and Co. 140 Broadway, New York, N. Y. 10005

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The Notes in brief are that **Willard E. Simpson** is executive Vice President of W. E. Simpson Co., Inc., consulting engineers in Civil-Structural Engineering practice. The firm was founded in 1909 by his grandfather (of the same name), a member of the Class of 1905. **John R. Kane**, Vice President for Engineering at Newport News Shipbuilding, has been named Engineer of the year by the Peninsula Chapter, Virginia Society of Professional Engineers. John pioneered efforts in the first major application of high-pressure/high temperature systems and boilers for ship propulsion. . . . **Ted Gundlach** advises that he has finally received his advance degree—"Granpaw"

with the arrival of Jonathan Andrew Gundlach on March 9, 1973, the son of Dr. and Mrs. T. J. Gundlach, III. . . . **Stewart Miller**, Director of the Guided Wave Research Laboratory at Bell Labs, has been elected into membership in the National Academy of Engineering. He has been engaged in research in guided wave systems and associated millimeter and microwave techniques. Please write **Al Guttag**, Secretary, Cushman, Darby and Cushman, 1801 K St., N.W., Washington, D.C. 20006

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A note from **Adrian Marcuse** accounts for his three young ladies as follows: Nancy after graduating from Wellesley is a management trainee at Filene's; Sally is a freshman at B.U. and Liz is in grade school. . . . **Reece Wengenroth** was installed as Vice President of the Consulting Engineers Council of Illinois in April. He is Executive Vice President of the firm of Westenhoff and Novick a Chicago based firm specializing in transportation projects. . . . **Newman Marsilius** was honored by the Bridgeport, Connecticut chapter of the University Professors for Academic Order at the University of Bridgeport. Newman is a former chairman of the board of trustees of the University. He is President of the Producto Machine Co., in Bridgeport. . . . **Lawrence E. Beckley** has been appointed Assistant Director of the Center for Space Research. He had been Administrative Officer of the Center since 1963 and prior to that was Manager of the Aeroelastic and Structures Research Laboratory.

Dr. **Herman Feshbach** who received his Ph.D. with us and who is currently director of the M.I.T. Center for Theoretical Physics has been named recipient of the American Physics Society's 1973 Tom W. Bonner prize.

Our Class was represented at the 25th Annual M.I.T. Fiesta in Mexico City by Dorothy and **Floyd Lyon**, Kay and **Jon Noyes** Betty and **Charlie Speas** and by Jeanne and **Bill Twaddle**. This is a great affair and as usual, a fine time was had by all . . . M.I.T. night at the United Nations featured a swinging black tie cocktail hour, a fine meal and an address by Secretary-General Kurt Waldheim. The evening was well attended including 1942's **Alan Katzensteins**, **Gaza Neumans**, **Doug McConnells** **Frank Staszeskys**, **Jim Sterns**, and your Secretary and spouse.—**Ken Rosett,** Secretary, 191 Albemarle Rd., White Plains, N.Y. 10605

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No one ever seems to write to me. I am lonelier than the Maytag repair man. Not really, of course, with seven children still running around the place. The three youngest ones and I just finished a small vegetable garden, the first one I have completed since back in high school days early in the war. I am lying here recuperating from the aches that are surfacing in muscles I seldom use. Before working on the garden we went to our local Memorial Day parade complete with both of the high school bands, Fairview and Lutheran West, an aging but surprisingly slim American Legion group, coveys of cub scouts, girl scouts, bicycle riders and auxiliary police. Rather an old fashioned type of parade, but very nice and meaningful. Earlier we put our oldest son, Joe, and our second daughter, Lisa, on the bus back to Columbus for their last two weeks at Ohio State University. Joe is completing his bachelors in Art History and will be going on for a master's degree. He is very good in this line but I wonder for him at job time. But that is what he wants, that is what he loves and does well, and so what else should we do but to continue to support and encourage him in this direction.

Lisa, our third, is completing her second year at O.S.U. and is planning to be a primary school teacher. Joan, our oldest daughter is finishing her third year at O.S.U. She is a history and English major. Joan will be working for a book publisher.

Our next child, Paul, graduates from high school in ten days. He plans to work in the aluminum foundry for a year in order to earn money for a used sports car and money for a three-month trip through Europe next summer. He plans to go on to further schooling in the fall of 1974. The rest of the children are all well and healthy. We have two remaining in high school and four in primary school.

Fred R. Park has recently joined Xerox Corp., as Editor of Corporate Publications with his headquarters at Stanford, Conn. Ford will be responsible for the Xerox Multinational News and other internal communications projects. Previously Ford was with Technology Communications, Inc., as Senior Editor of *Innovation Magazine,* Conover Mast Inc., as a Senior Editor, Design Engineer at Line Div., of Union Carbide and Professor of Engineering at the University of Buffalo. Fred, his wife and three children live in White Plains, N.Y.

A brief note from **Dave Moyer** advises he is now Director of System Research at Ford Motor. Dave has been flying single engine planes and now is starting to fly twin engine planes. The Moyers have four children; two boys out on their own; daughter, Sally, at Michigan State University, and daughter, Robin, in high school. Dave says he occasionally sees classmate, **Jim Chabot**, Chief Engineer at the Ford Design Center. . . . A fine note from **John Maynard** in his twenty-six year at Honeywell in Minneapolis. John travels in the U.S. visiting Honeywell division engineering departments, helping them to improve their design efficiency through the use of computers. John wishes to announce he and Jan are now grandparents.

Robert M. Adams, Dean of the Social Sciences at the University of Chicago, has been appointed Chairman of the Assembly of Behavioral and Social Sciences. Until next time.—**Russell K. Dostal**, Secretary, 18837 Palm Circle, Cleveland, Oh. 44126

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Business activity is high, inflation is wild and the golf season is here but some of you should be able to drop us a line.

Betty and **Don Espey** of Houston were our Class attendees at the M.I.T. Fiesta in Mexico City. I saw Clarence Westaway, '33, at the Power Conference in Chicago last week and he commented that his trip to the Mexican affair was most enjoyable. . . . From the clipping services we learn that Bethlehem Steel has named **Bill Adams** as Credit Manager supervising activities in the Boston, Buffalo, Philadelphia and New York sales districts. Bill has been with Bethlehem since graduation spending essentially all of his career in the finance department. . . . Analog Devices of Norwood, Mass., has named **Cyril Brown** Manager-Advanced Product Planning. . . . **Bob Corless** has been promoted from President of American Olean Tile Co., to Group Vice President of the firm's parent organization, National Gypsum Co. He will now be responsible for the Multicolor Division as well as the Ceramic Tile Div. It appears that Bob, wife Ellen and their four children will continue to reside in Ambler, Pa. . . . **Walt Kern** writes that he is still Chief Mechanical Engineer for Teradyne where the business climate is improving. He has bought a vacation house at Hilton Head, S.C., which should help his tennis game.

From the Reunion biographies: **Oiva R. Anderson**, Fox Farm Rd., New Ipswich, N.J. 03071. Oiva is President of both the A. F. Walker and Son Inc., and Accumetrics, Corp. His degrees are B.S., M.S., Course XVI. His wife is Annette Mitchell and they have three children; Carol, 21, Christine, 19 and Sharon, 18. Oiva is an Associate Fellow, A.I.A.A. and his hobbies are ski touring, hiking, antique house restoration.

After receiving his B.S. in '47 and M.S. in '48, he worked at the M.I.T. Naval Supersonic Laboratory until 1951. Subsequently, he worked in the Research Department of the United Aircraft Corp., in East Hartford, Conn., for three years. From 1954 to 1959 he was a Project Engineer for Allied Research Associates in Boston. He then joined American Science and Engineering Inc. in Cambridge eventually becoming Vice President of the Engineering Sciences Division. In 1966, he left A.S.E. to start Accumetrics Corp., in Cambridge. Just this spring, he has acquired A. F. Walker & Son Inc., which is a manufacturer of high quality hardwood turnings for the furniture, cutlery, hardware, toy, sporting goods, musical instrument industries.

Moving to New Hampshire from the Boston area represents a return after 29 years to where he started from! Their oldest daughter will be graduating from Tufts this spring. Number two daughter is a sophomore at Brown and the youngest will be entering University of New Hampshire this fall. Wife Annette teaches second grade in the local public school and attends graduate school in the evenings.

Thomas L. Bell, Jr., Hidden Lane, Cazanovia, N.Y., 13035 is Vice President and General Manager of Lipe-Rollway Corp., in Syracuse. He has a B.S. Course XV degree. He married Ellen Wiggins and has four children; Mary, 22, John, 19, Tom, 15 and Bob, 13. His hobbies are tennis and sailing. After release from the

army in September of 1946, he returned to M.I.T. and received a B.S. in Course XV in September of 1947. With classmates **Bob Creek** and **Chuck Morton**, he joined DeFlorez Engineers of New York City on consulting engineering assignments in Long Island and Pennsylvania. In 1948, shortly after he joined a packaging materials division of Johnson and Johnson in Brunswick, N. J., as an I.E., he married Ellen whom he had first met when a sophomore at Tech in 1942. After several years and the birth of their daughter (Mary), they left New Jersey for California as a result of his decision to work for a container manufacturing division of Bristol Myers setting up a new branch plant operation.

In 1953, they returned to the East as he had joined Booz, Allen and Hamilton in New York. For most of the next six years they lived in Old Greenwich, Conn., and he enjoyed the varied assignments of a management consultant. One required moving for a winter to Sault Ste. Marie, Ontario and another required a move to Egypt where he was an advisor to the Egyptian Government. After returning to Connecticut where their second son (Tom) was born, they opted for more stability and he joined a Rochester, N.Y., business products of Itek Corp., in 1958 as Sales Manager and later became General Manager. In 1965 he resigned to become a Vice President in the Business Equipment Group of Bell and Howell in Chicago. In 1968 they decided it was time to settle down. He joined Lipe-Rollway Corp., a Syracuse manufacturer of heavy duty clutches, cylindrical roller bearings and automation equipment, and they moved to a home on the lake in nearby Cazenovia. He feels his work is most interesting and challenging as he is now very much involved in starting up operations in Europe and Australia in addition to expanding them in Syracuse.

Until next month—try to write. **Dick O'Donnell**, Secretary, 28516 Lincoln Rd., Bay Village, Ohio 44140

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This column is being written three days before our 25th Reunion begins. One hundred classmates have registered for the Reunion. Attendance including wives and children will be about 300 people. The program is complete and the committee is relaxed awaiting a pleasant gathering.

As usual a great deal of the actual implementation of a Reunion becomes the responsibility of a few people. **Sonny Monosson** was involved in all of the planning, but he also arranged for many specific functions such as preparing publicity and mailings, publishing the yearbook, renting the Essex County Club, and a band. Sonny was always there when he was needed. The Class is fortunate to have had Sonny as Class President and a Co-Chairman of the Reunion.

Bob Sandman put organization into the program for adults and for children. He was in touch with some facet of every day's program. Bob also arranged for a printer for the yearbook. . . . **Leon LaFreniere** arranged a series of meals that were so attractive that when Leon read the menus to the committee we were in a state of caloric exhaustion anticipating the feasting that Leon was describing. . . . **Dave Finnegan** really put in the personal touch with his efforts of manufacturing 250 beavers to be given as souvenirs at our Reunion. . . . Not visible at Reunion Committee meetings were the efforts of **Jack Page** and his committee to solicit the class gift. Also the Regional Chairman who contacted classmates to invite them to the Reunion. Summary letters were received from **Paul Erskine**, Los Angeles; **Dick Baker**, New York; **Ed Bell**, Dallas; **Frank Jamerson**, Detroit; **Ed Mack**, Wisconsin; **Ellis Barron**, Washington, reporting on expected attendance at the Reunion.

Without the efforts of **Charlie Adams**, **George Clifford**, **Ted Yoos**, **Marvin Rosenberg**, **Nick Caldwell**, **Don Noble**, **Dick Harris**, **Ken Brock**, **Dave Vigodo**, **Stan Shein**, **Herb Lipson**, **Herb Marcus**, **Art Waxman**, **Verity Smith**, and others, the Reunion could not have occurred. Joe Martori and Dick Knight of the Alumni Association also helped the Reunion Committee: our thanks to them.

The mail included a note from **E. Neil Helmers** who has transferred to Newark, Del., from Old Hickory, Tenn. Neil was there for nine years. DuPont has assigned Neil as Manager-Regional Offices of the Engineering Services Division. . . . **Douglas V. Hutchins** has been with Grumman Aerospace Corporation for 22 years as Stress Analyst. He has worked on Gulfstream I, E-2A, F-111 and lately has been responsible for structural integrity of electron-beam welded Titanium, wing center section for the Grumman F-14A. Neil is married with four children. His eldest daughter graduates from Waynesburg College this semester. . . . **Merle K. Loken** was certified in 1972 by the American Board of Nuclear Medicine. Since 1963 he has been the Director of Division of Nuclear Medicine at the University of Minnesota Medical Center. Merle received his Ph.D. in Biophysics in 1956 and his M.D. in 1961 from University of Minnesota.

Lester Corrsin is still living in New Paltz, N.Y., where he is consulting in A.P.L. computing and reprography. He is considering a new venture in liquid crystal displays. . . . **Vic Pomper** graduated from the Advanced Management Program of Harvard Business School in May of this year. Vic spent 90 days at Harvard. **Herb Marcus**, back from skiing in Canada has begun his plans to race his new 41 foot sloop, "Tartan" in the Southern Ocean Racing Circuit. . . . **Sheldon Kaplan** became Chief Executive Officer of Evans Products Co., in January.

Since graduation many classmates have died in accidents and from disease. The following list of deceased classmates is based on current records at the Alumni Office: John C. Adams, Jr., 1960; James N. Addoms, 1958; Norman M. Arnstein, 1954; Verl C. Athey, 1953; John J. Benjamin, 1958; Hans H. Bernhardt, 1962; Louis F. Blanc, 1961; Robert G. Brochard, 1958; James Hanbury Burrell, Jr., 1949; Sylvan L. Cahn, 1967; Dr. Chen Chu, 1961; Charles F. Coit, 1960; John P. Comer, Jr., 1969; Robert E. Conwell, 1958; Emil W. Delu, 1953; Robert L. Deming, 1967; Vincent Anthony Dolan, 1949; Arthur Joseph Donnelly, 1950; John J. Downing, Jr., 1968; John P. Dyer, 1970; Philip J. Friedlander, 1972; Charles A. Gibbons, 1971; James David Graziadei, 1950; Robert W. Griffin, 1971; Charles F. Hobbs, 1969; Harlan F. Hunt, 1962; Juan I. Irigoyen; D. Anson Isely, 1971; Peter D. Johnson 1962; William Campbell Jones, 1946; Benjamin Kessel, 1971; Harold Kilgore, 1972; W. Scott Knowles, 1965; Myron G. H. Ligda, 1967; Ian H. Mac Donald, 1971; Osmo A. P. Makkonen, 1960; George H. Maringas, 1961; George J. Maritz, 1967; Earle R. Marshall, 1960; Lemuel W. Mason, Jr., 1966; John F. Matthews, 1965; Henry C. Maulshagen, 1964; Ian H. McDonald; Lieutenant Colonel Thomas F. McGraw, 1965; Lieutenant Joe L. Midgett, 1967; Richard H. Miller, 1959; Donald C. Mork, 1964; Joseph E. Nelson, 1949; Benjamin Marvin Newmark, 1950; Preston A. Padon, 1955; Roger V. Parlett, 1948; George R. Pepin, 1969; James J. Rattray, 1972; Barrett Irwin Rubin, 1948; Earl O. Ruhlig, 1953; Leonard P. Salter, 1965; Harvey H. Salwen, 1955; John H. Savage, 1964; John E. Schmidt, 1972; Claudio P. Segre, 1971; Charles B. Silver, 2nd, 1960; Benjamin McNeil Smith, 1946; Martin O. Sorensen, 1963; F. Patterson Spencer, 1964; Carl Landis Stahle, 1946; Ralph L. Strean, 1954; James Housel Thomas, 1949; Kenneth M. Thompson, 1961; Carl Thomsen, Jr., 1958; Giacomo Mario Tofani, 1949; Frank Viera, Jr., 1966; George R. Walden, 1960; John H. Wright, 1967.

Our sympathy is offered to the families of these men.—**S. Martin Billett**, 16 Greenwood Ave., Barrington, R.I. 02806

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Stanley N. Kuryla died March 12, 1973. A member of Sigma Chi, he graduated in Business and Engineering Administration. Alumni Registers indicate an extended career with Ford Motor Co.: Programming Manager, Finance Staff in Dearborn in 1961; General Manager, Ford of Mexico in 1967; and Controller, Ford Motor Co., Product Development Group, at his death. Our condolences go to his wife Beverly, sons Michael, Mark and Timothy, and daughters Kathleen and Mary.

There is happier news from other classmates via Alumni Fund envelopes: **Charles Davis** reports improbably "Fully matriculated sophomore in University of Washington School of Nursing, heading for academic nursing degree. Those 240 girls with photographic minds (the rest in blue jeans) aren't making the eight men look like idiots. We do it all ourselves. Extraordinary faculty and curriculum." Noel (Skip Davis says that his son, Noel B., who started M.I.T. this fall, "is an enthusiastic about it as I was." . . . **Leonard E. Meyer** is an architect with the Office of Construction, Veterans Administration, dealing with additions to and renovation of hospitals throughout the U.S. . . . **Peter St. Germain's** post-graduation history: "Following a year in the oil fields with Texaco and five years in research with Sperry Gyroscope, I joined the investment banking firm of Morgan

Stanley and Co., becoming a partner thereof in 1968." **George Tomlinson's** stream of consciousness: "In charge of advanced planning section . . . have begun further studies on library and related problems . . . updated and completed Milwaukee master plan and playground program . . . I've begun to work with community theatre, have been in two plays . . . hoping for a break to get back to California."

James Veras joined Amerada Hess Corporation in February 1970 as Assistant to the Chairman of the Board. This February, he was elected Vice President of Sales. Congratulations. Best wishes to all classmates.—**Frank T. Hulswit**, Secretary, Acorn Park, Cambridge, Mass. 02140

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H. P. Hayden continues to work on I.B.M.'s processor memories and, now, their power supplies at Essex Junction (near Burlington) Vermont. . . . Professor **Paul Kruger** has just coedited first book of geothermal energy with Carel Otte, Vice President of Union Oil Co. of California, being published by Stanford University Press. . . . **Loris M. Hailey, Jr.**, is still with L.T.V. Aerospace (since January 1970) in newly formed "Ground Transportation Division." He is responsible for digital computers (nine)—selection, installation, programmming—used to monitor and supervise the fully automatic "Airtrans" inter-airline transportation system for the new Dallas/Fort Worth Regional Airport (people/bags/mail/trash/supplies).

After 12 years in business, **A. James Fuller** went back to Law School. He has been practicing on his own for the past five years and thoroughly enjoying it. . . . **Gerald Peretsman** has been named to the position of Executive Vice President of Downe Communications, Inc. Mr. Peretsman will be in charge of the direct marketing group, a new office that consolidates all mail-order selling and distribution of goods and services. This includes the insurance marketing division, Greenland Studios, Joy's Ltd. (direct mail) and Hamilton Mint (producer of commemorative plates and medallions) and other products and services sold by mail. Mr. Peretsman spent the last seven years with I.T.T. as Vice President. He also served on the controller's staff of the Mobil Oil Co.—**John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

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Well, we are beginning our pregnancy! Nine months from now, we expect to bring forth our Reunion. We suspect it will not be without the usual morning sickness and birthpains but also expect that wonderful feeling of seeing and reacting to the new born. This Reunion might just be the best yet. **Bob Warshawer** is enthusiastic. He reports that over 100 responses have been received and that most of them favor going to Bermuda. Arlene and **Harvey Steinberg** indicate that letters are arriving from all parts of the world. The first response was a two-page letter from the Chancellor. **Paul Gray's** letter contained many valuable suggestions. Let's hear from the rest of you. Cookie and **Herb Slater** of Glen Cove, N.Y., and Eileen and **Joe Blake** of Medford, Mass., will be Vice Chairman of the Reunion. **Howes** and **Masison** volunteered to be chairman of vice but were turned down.

Need any nose cones welded? **Russ Chihoski** as head of the welding research at Martin Marietta Corp., in Denver has come up with a new system to assess the reliability of resistance spot welds. Among the 12000 welds made by Martin Marietta in the first use of this system, less than 70 were considered anomalous. Russ feels that this system can work with any metal and also looks very promising for use with the popular weld-bonding process.

George Bortolomei has recently returned to sunny San Diego after spending five years in sunny Pennsylvania. George is Chief Engineer for Design Effectiveness and Drafting at International Harvester's Solar Division. . . . **F. B. Latini** is Administrative Manager for the construction of Europe's largest alumena plant in Sardinia. He had been Resident Manager of Kaiser Engineer's Rome Office which he established in 1969. . . . A returning classmate, is **Bob Macintosh** who expects to return this summer after heading up the U.S. Army Missile Command's Heidelberg Field Office for two and one-half years.

Dave Sternlight, Director of Economic Planning at Litton, is spending a year with the Department of Commerce in Washington as part of a program in which business and government swap expertise. . . . **Dick Hayes** has been named Vice President of Copier Product Development at Xerox and **Dave Whelpley**, after 14 years with Roadway express, has joined Jones Motor of Spring City, Pennsylvania as Executive Vice President of Finance.

For those of you who have been reading this column carefully, among other things, you may have noticed some similiarity with the news in the March/April column. **Latini** is in the same general activity as **Dick Sherwood** who is Chief Civil Engineer for a large aluminum refinery and **Sternlight** joins **Avron Spector** in Washington, Avron as a Presidential Interchange Executive with the F.A.A.

OK you West Coasters, it only costs 8¢ to mail in from there—so who can update us on **Tom Henderson**, **Coley Bresee**, **Sam Losh**, and all the rest? Take thy pen in hand and drop a line or two to—**Dave Howes**, Box 68, Carlisle, Mass. 10741 or **Chuck Masison**, 76 Spellman Rd., Westwood, Mass. 02090

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Summer is now upon us, and taking out the boat means enlisting the children as crew. Does it seem that long ago that you were sailing a dinghy on the Charles? At M.I.T., two Class members were promoted to the rank of professor this year. **Frank E. Perkins** of the Department of Civil Engineering and **Ranier Weiss** of the Department of Physics are the newly-appointed full professors. . . . At Purdue University, **John Lindenlaub** was the General Chairman of the 1973 Frontiers in Education conference, held in April.

Joseph A. Lombardo has received the N.A.S.A. Exceptional Service Medal. He was presented this award in April by N.A.S.A. Administrator Dr. James Fletcher for his outstanding contributions to the Apollo lunar landing program. He has been at the Marshall Space Flight Center since it was formed in 1960. . . . Combustion Engineering, Inc., has appointed **Robert N. Duncan** to the position of Manager of Core Materials in their Windsor Nuclear Laboratories. His responsibilities include the development and testing of core materials such as nuclear fuel, cladding, and reactor control materials. He joined Combustion Engineering in 1972. . . . **Ed Elizondo** is presently a communications systems engineer on the atmospheric explorer spacecraft, which is scheduled for launch in November. . . . In August 1972 **Jose Garnica Ortiz** was appointed General Manager of the Consumer Product Department of General Electric de Mexico, and in September of that year he was elected Vice President of the company. . . . **Marsbed Hablanian** is the Manager of Engineering at the Varian Vacuum Division plant in Lexington, Mass. . . . **Joyce P. Davis** has been appointed to the Environmental Radiation Exposure Advisory Committee of the U.S. Environmental Protection Agency.

A recent notice from Dorrance and Co., publishers, concerns the activities of **John A. Sullivan**, who is Chief Metallurgist at Alan Wood Steel Co. John has published a book titled *Mental Gymnastics*, which is a mental exercise program of puzzles and problems. John and his wife Marie have five children, Kathy, John, Joan, Bill, and Ellen.—**Allan C. Schell**, Secretary, 19 Wedgemere Ave., Winchester, Mass. 01890

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Joseph Gaziano has been elected President, Chairman and Chief Executive Officer of Tyco Labs in Waltham. Joe was formerly President of Prelude Corp., in Westport. Dr. **Sigurd Hoyer** is Vice President of Research and Development for Potter Instrument. Potter specializes in producing computer peripheral equipment. Prior to his work at Potter, Sigurd spent four years with Fairchild Industries and three years with A.V.C.O. Sigurd and Astrid have five children and live in Huntington, Long Island. . . . **Al Kezer** has formed his own company, Allen Technology, Inc. The company will make electronic function modules for industrial controls. The plant will be in Whitinsville, Mass. . . . Is that our **Larry Moss** who has been elected President of the Sierra Club? . . . Dr. **John Newman** of Tech's Naval Architecture Department has been elected a Guggenheim Fellow for 1973 to study theoretical marine hydrodynamics. . . . On the local scene, **Lloyd Beckett** and **Graydon Wheaton** were elected town meeting members in Lexington, Mass.—Cosecretaries: **Bruce B.**

Bredehoft, Secretary, 3 Knollwood Dr., Dover, Mass. 02030; **Mrs. Lloyd Gilson**, 35 Partridge Rd., Lexington, Mass. 02173

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Rosalie and **Bob Rosen** are on a two-year visit in Aarhus, Denmark ("The second largest city—or largest village—in Denmark") where Bob is a guest professor of Computer Science. Bob writes: "Danish has been a great challenge for us and a great lesson in tolerance too. Of course our children, aged 7 and 4, are already fluent. Sasiger hilsen til alle." . . . **Bob Sanborn** sent us the following biographical notes: "After graduation I spent three years in Research and Development with Philco Ford Corp., and 11 years in Semiconductor Marketing and Sales with Philco Ford, Motorola, I.R.C., Hughes, and General Instrument before entering into the Sales Representative business. I now have a major interest and am Vice President of Varijon Associates of Los Angeles. My wife Sandy and I have a daughter, 14 and a son, 3." . . . **Barney Silver** is Chief Engineer of the Union Sugar Division of the Consolidated Foods Corp., and President of Silver Enterprises, a sugar technology consulting and engineering firm. . . . **Peter Samton** has been promoted to the position of Design Director with the architectural, planning, and engineering firm of Gruzen and Partners. The press release that accompanied the announcement gave the following information on Peter: "Before joining Gruzen and Partners, Samton served briefly as head of his own firm which specialized in recreational facility and school design in New York and New England. From 1960 to 1962, he worked in the New York City architectural office of Marcel Breuer.

Previously, after a stint with the U.S. Army at Fort Dix, N.J., Samton worked in the Cambridge, Mass., office of Hugh Stubbins from 1959 to 1960. There, he served as design captain of the Maimonides School in Brookline, Mass., which won first prize in the 1963 Boston Arts Festival.

In 1961, Samton and his brother, Claude, also an architect, were members of a design team which was named a finalist in the Franklin D. Roosevelt Memorial competition in Washington, D.C. Samton is a registered architect of New York, New Jersey, and Massachusetts and is certified by the National Council of Architectural Registration Boards. He is a member of the American Institute of Architects (A.I.A.) and the New York State Association of Architects, A.I.A. He also is a member of the New York City chapter of the A.I.A. and serves on its Medal of Honor and Award of Merit Jury. He has served also as a visiting design critic at New York University, Columbia University, North Carolina State University, M.I.T., and City College of New York of the City University of New York.

Samton graduated first in his class in 1957 from M.I.T. where he earned his bachelor of architecture degree and a Silver School Medal from the A.I.A. He is a member of Tau Beta Pi, the engineering honor society, as well as the Ameri-

(Continued on p 138)

"Walking in a tunnel with three feet of water and a four-foot ceiling . . ."

Patricia P. Crowther, '64
Cartographer, Cave Research Foundation

The following description of explorations through which were linked the Flint Ridge and Mammouth Caves of Kentucky, proving them by far the largest cave system in the world, is condensed from Mrs. Crowther's account in Saturday Review of the Sciences *for April, 1973. (See "Discovering the World's Biggest Cave," Saturday Review of the Sciences, March 24, 1973, pp. 70-74. Copyright 1973 Saturday Review Co.)*

I was underground for part of the Memorial Day weekend of 1972—deep inside the catacombs of Kentucky's Flint Ridge Cave System. While thousands of holiday visitors walked along well-marked routes in other areas of the caves, I was lying on my back in the mud, 380 feet underground, trying to dig past a rock pile. I was searching for a new passageway that I hoped would connect the Mammoth and Flint Ridge cave systems.

I had hoped that the day's exploration might show us the elusive passage from Flint Ridge to Mammoth. Discovery of a connecting passageway would be a very dramatic development in speleology (the science of caves). The Flint Ridge system, with some 87 miles of surveyed tunnels, was already the world's largest cave, and Mammoth, with 58 miles of known passages, was third largest. Discovery of a connection would show the complex to be one continuous labyrinth about twice as extensive as the world's second largest, the 72-mile Holloch Holle in Switzerland.

My own cave research began during my undergraduate days at M.I.T. I met my husband underground in a cave in New York; Will and I spent our honeymoon exploring the confusing labyrinths of Breathing Cave in Virginia. When friends recruited us for field trips in Mammoth Cave National Park in 1969, we eagerly locked our house and headed for the Cave Research Foundation headquarters in the Park. As we became involved with C.R.F., we were able to offer some specialized help in tracing the maze, because we both work with computers. Our home literally became a map factory, filled with survey books, maps, and computer printouts. A corner of the living room held a computer terminal. As it turned out, we were able to "teach" the computer to plot survey maps. We could never otherwise have dealt with the flood of data gathered in 30 miles of passages during a three-year surveying program.

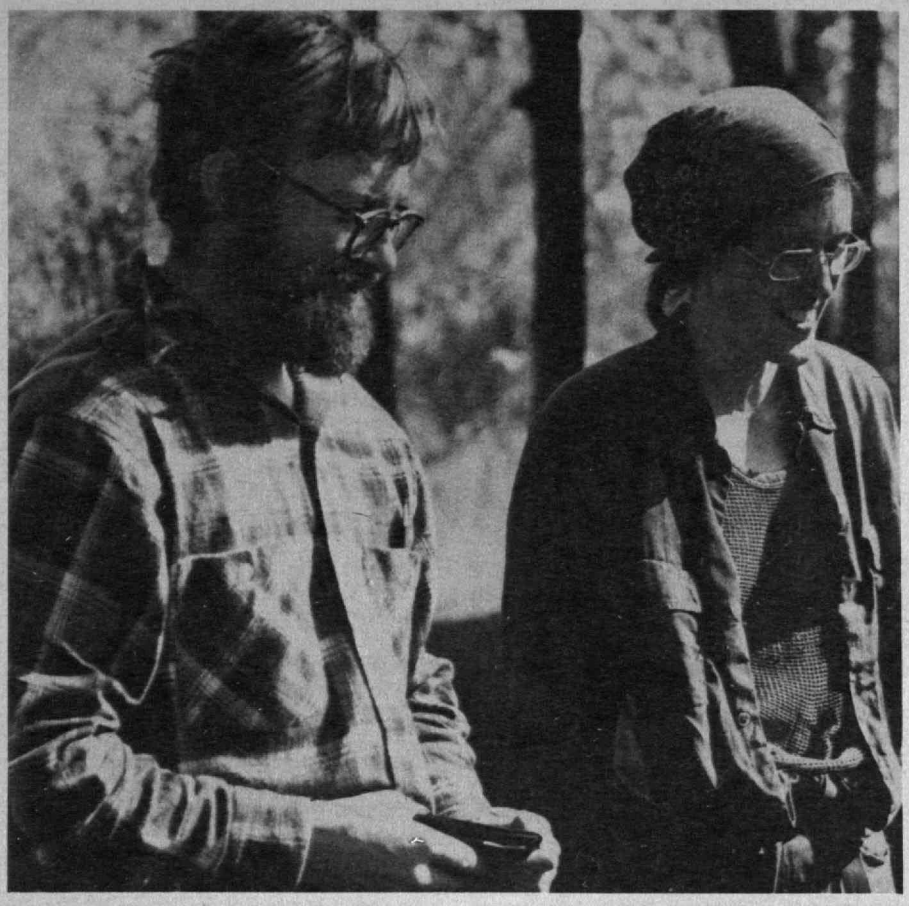
The real thrill, however, came from caving itself. We had stopped at a rock pile on Memorial Day weekend; I itched to return to Flint Ridge and in July I got my chance. Will thought the passage we had tried was hopeless, but I returned to it anyway. We worked our way backward from the rock pile, checking every tiny hole leading off to the side.

After two hours, only 1,600 feet back from the rock pile, we were following a side passage, a belly crawl in muddy water, to its end. While one of the others tried to move a rock that was firmly wedged across the end of the passage, I slipped down to the left to a crevice less than a foot high and found a new passage, 100 feet of almost dry crawl space that led to a little pit, where loud rushing water noises came out of a small canyon in the floor. I followed the canyon until it was less than eight inches wide, then climbed up and wriggled on my side through a slight widening at the ceiling. The walls opened out again above a stream leading to a ten-foot waterfall in a large room. A small drain appeared to head west out the bottom. Because no one knew where I was, I didn't try to climb down; but I knew I had a real, live, going lead.

A month later, in August, an exploration team went straight to my little drain lead. They surveyed to where I had stopped; then, going past the spot that had stopped me one of the team, Tom Brucker, pressed on to a strange river and followed it for 1,200 feet, first on all fours and then on foot in an eight-foot-high tunnel that housed cave blindfish and crayfish. The river was a major discovery.

On August 30 I was at Flint Ridge again, excited by the possibility that this new river might lead to Mammoth Cave. We set off in high spirits, singing the "Tight Tube Blues" badly offkey and doing the "Bretz River Shuffle"—named after a particularly narrow stretch of tunnel where you have to walk sideways. We started our survey through the drain, turning right at the river. We slogged downstream, stoop-walking through pools with gravel sandbars, on and on.

Tom Brucker's initials in the mudbank marked his farthest penetration along the river, and we moved past them through virgin cave. We sloshed ahead on hands and knees in shallow water, getting wetter and colder. The Tom and Richard Zopf were yelling up ahead—what for? When I came up to them, they were in a small room, pointing at a mudbank. There, clearly revealed in the yellow glow of the carbide lamp, was an arrow scratched in a mudbank, pointing downstream, the direction we were headed. On another wall we saw faint letters, which we deciphered as reading PETE H. Pete H. was telling us that he had come from the direction we were heading. Mammoth at last? We had seen arrows like this in Mammoth itself! They belonged to Pete Hanson, a Mammoth Cave guide and a leader on the trip that found the New Discovery section of Mammoth Cave in 1938. The letters were probably 34 years old.



There are two sides to Patricia P. Crother, '64, in these photos. In caving attire, (above) she and her husband, Will, set about exploring the Flint Ridge Cave system. At right Patricia is back at the business of mapping passages with the aid of a computer.

We whooped for joy, for we knew that at last we had connected with Mammoth Cave. No doubt this was Pete's farthest penetration. But where were we exactly? I set a one-hour time limit, and we followed the stream at a brisk pace; it swelled and turned south, diving right under passages in Mammoth Cave. We trudged in bent-over fashion, thigh-deep in water, our backs aching. We kept walking. After a mile we could stand up briefly. The passage continued, but we were out of time and our energy reserves were drained. We left our own initials on a wall, still not knowing where in Mammoth we were, then shifted our minds into automatic for the five-mile return trip. Finally, after 21 hours underground, we came out of Flint Ridge just as the bats were flying in for the day.

We experienced an indescribable feeling, having entered Mammoth Cave from Flint Ridge for the first time—something like having a baby. You had to keep reminding yourself that it was real, this new creature you have brought into the world that wasn't here yesterday—the Flint Mammoth Cave System.

On September 9 I returned to Flint Ridge to join a group of strong, thin cavers. We had four compasses and two survey tapes, as well as candy bars, tinned meat, and cans of fruit. We set up a leapfrog survey from the last station near PETE H. and the arrow. All went smoothly, hour after hour. At the end of our second survey jump, we came upon the other party, 600 feet from where we had left our initials on the previous trip. They had had the hardest part of the survey and were ready to quit for the day. We waded on to the initials, then proceeded to unfamiliar cave. After 450 feet the mud-covered ceiling dipped lower and lower. Soon we were walking in a tunnel with three feet of water and a four-foot ceiling. We tried not to make waves, since there was only a foot of space for our heads.

John Wilcox is in front. "The ceiling is rising. I see a tourist trail!" he says. We are yelling now. Zopf sticks on a projection. We push him hard and shove him through. We sink chest-deep in water, lay our ears next to the water, and float out into a black vault, which looks like a moonless, starless night. On the far shore we see the linear outlines of a steel pipe railing atop a man-made rock walkway. I feel weirdly disoriented, seeing this artificial construction in the far reaches of a wild cave. Where are we?

The wading is easy, but I slip on an underwater rock and sit in the water up to my neck, soaking a third compass. Finally we all recognize where we are—Cascade Hall near Echo River, where the boat landing used to be. Although tours no longer go this way, millions of Mammoth Cave visitors have passed by the little hole we came through. We plunge back into the water and complete our survey of the new connection, so we can tie it into an earlier survey C.R.F. had made in Mammoth Cave's Cascade Hall. We joke about "driving the golden spike."

We left Mammoth Cave early in the morning of September 10 by way of the elevator in Snowball Dining Room, thus completing the first portal-to-portal trip into Flint Ridge and out of Mammoth Cave. Even soaked to the skin and with mud on our faces, none of us could stop smiling, for we had just "climbed the Everest" of speleology. We posed for a souvenir photo and later relived the 16-hour trip in the Pinnix living room over a bottle of long-saved champagne.

When I got home later that day, I sat down at the teletype to tell the computer about our surveys. The plotter drew the map for me—*then* I could sleep, knowing that the new Flint Mammoth Cave System is the most extensive in the world, with more than 144.4 miles of surveyed passages.

(Continued from p. 136)
can Arbitration Association and the Regional Plan Association. In 1958, he studied in Paris on a Fulbright Fellowship and worked briefly in the Danish architectural office of Gunnlogsson and Neilson on the team which was named a finalist in the Toronto City Hall competition. Samton and his wife, the former Emily Leshan of New York City, have two sons, 5 and 3½. They live in Manhattan."—**Fred L. Morefield**, Secretary, c/o Mobil Oil Caribe, Inc., P.O. Box X, Caparra Heights Station, Puerto Rico 00922

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Well, having broken my consecutive-issue hitting streak well short of Joe Dimaggio's 56 straight, I take pen in hand and begin again.

Last April, **George Phipps** conducted a four-part series, "Cross Sections of Litchfield Country Architecture" as part of Northwestern Connecticut Community College's Community Service program. George received his M.S. degree in architecture at Columbia University and is currently employed by Fairchild, Rollis, Fairchild, architects of Hartford. . . . **Neil Harper** writes that he has started a new firm, Neil Harper Associates to specialize in information systems, financial management systems, architectural and engineering applications.

Myer Kutz and I were co-godparents recently for a mutual friend at an Italian christening. Talk about your ecumenical movement! Myer and his wife Cynthia, each having completed a book to be published in the fall, are spending six months in Europe relaxing and gathering material for future literary endeavors.

I recently received a copy of a fascinating article from the Honeywell Computer Journal written by **Al Beard** entitled, "Figure Skating and Computers". Al, who is a systems engineer at Honeywell's Phoenix Computer Operations has combined his vocational talents with his avocational interests in figure skating to produce a truly remarkable system. Any of you 59'ers who show an interest in sports will find the article most interesting. If you would like to receive a copy let me know and I will forward one to you.

Jim Poor has been named Director of the A.E.C.'s Division of International Security Affairs. This Division is responsible for Commission's arms control, political-military security affairs, mutual defense agreement and intelligence functions. Jim who was with the Avco Corp., Mitre Corp. and the Department of Defense before joining the A.E.C. in October 1972, lives in Alexandria, Va., with his wife and two daughters.

Jim Conklin has been named Associate Director for Instruction and Research Computing of the Northeast Regional Data Center in Gainesville, Fla. Jim was an Associate Professor of Physics at the University of Florida, and has been active on the University Computer Advisory Committee.

A news release from the Computer Sciences Corp., announced the appointment of **Bob Langelier** to the position of Vice President of that company's Systems Division in Falls Church, Va. Bob formerly was Director for Advanced Systems and Technology in the office of the Assistant Secretary of Defense and has been active in improving the management of the Defense Department's world-wide military command and control system. Bob has his doctorate from Purdue University and is a member of the I.E.E.E. . . . **Gerry Stephenson** dropped me a back-of-the-envelope note which said, "Since I saw you last, Barbara and I have a son, Tommy, born March 1, 1970. I am now an Associate Professor of Physics at University of Maryland (there since '66, rank since '69). Am currently enjoying a sabbatical on a Guggenheim Fellowship, spending most of the year at Los Alamos and then working my way back to Maryland by way of London and Munich. Enjoy professoring immensely. Give my best to all 59'ers you see in Boston". . . . **Marty King** writes that he is out of the service and in private practice of pathology in Corpus Christi, Texas. He and his wife Flora have two boys, David, 3½ and Anthony, 15 months. They all enjoy Texas very much.

Pete Luchini was recently named an associate partner in the firm of Bemis, Freeman and Sipala, consulting engineers of Hartford. . . . **Dick Talbot** dropped a note and said "Received Ph.D.—Aerospace Engineering from Air Force Institute of Technology in June 1972. Assigned as Technical Manager of Preliminary Design Group, Advanced Structures Branch, Structures Division, Air Force Flight Dynamics Laboratory, Wright-Patterson A.F.B. Group performs structural preliminary design studies to support advanced U.S.A.F. conceptual system design programs". . . . In an Israeli aerogramme, I learned from **Herbert Priluck** that he is just completing a very interesting four-year stint as Manager of the Negev Construction Office for the Israeli Defense Ministry and expects to be back in Brookline in late June. He asked me to convey his best regards to all 59'ers especially Course I grads and lacrosse players.

It is with deep regret that I pass on to you the news of the death of another of our classmates, **Ellery Stone** on May 31, 1973. At the time of his death Ellery was President of the Furnside Foundation of Chicago and employed by the Fidelity Management Research Co., of Boston. On behalf of the entire Class, may I extend our deepest sympathy to his widow, Gretchen, his children Ellery, Jr., and Robert, his family and friends. On that sad note, I end this month's column.—**A. J. Collias**, Secretary, 61 Highland Rd., Brookline, Mass. 02146

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Larry Turner informs us that he and his wife, Gail expected their first offspring in March. They are very excited and we wish them the best of luck. He also told us he was skiing with **Elliott Bayly** during a visit to Mr. Bayly's home in Colorado. **Phil Cassady** received his Ph.D. from the Aeronautics Department at CalTech in 1970. Since then, he has been at the Lockheed Research Laboratories in Palo Alto, Calif. His wife, two sons and he are living in Menlo Park, Calif. . . . **T. G. Burns** has now completed seven years in Germany, during which time Louise, his wife, and he have accumulated two small Frankfurters, aged 2 and 5. He is now General Operations Superintendent for Chevron Erdsel Deutschland.

Dr. **Albert J. Giramonti**, who is with the United Aircraft Research Laboratories, East Hartford, Conn., presented a paper on viable and competitive alternatives to both nuclear and fossil-fuel (coal- and oil-burning) systems for generating electric power at the 165th national meeting of the American Chemical Society before the Division of Fuel Chemistry in the Fairmont Hotel in Dallas, Tex., on April 11, 1973.—**Gerald L. Katell**, Secretary, 122 N. Maple Dr., Beverly Hills, Calif.

65

Missed last month's issue by a combination of short deadline and long trip to the Grand Canyon. But note the thinness of a column even with two months' news. Write dammit! ! **Ralph Cicerone** writes frequently with news of his continuing adventures in atmospheric research at Michigan. Ralph says he recently worked on aurora in Alaska with John Meriwether, '64. . . . **Phil Hoover** reports that he is now at anchor in Monterey, Calif., after seven years of sailing on and under the bounding main. (I guess that's Naval Post-Graduate School). Phil is working on a master's in engineering acoustics, wife Carol is going to school at Monterey Peninsula College, and sons Donald, Christopher and Thomas are in School. Phil would like to locate John Freed and Dave Howe. Any help? . . . **Dave Lerner** is going (went) to London in June. May never return. Sends regards to aulde friends. . . . **Jerry Robertson** and family will return to Cambridge this summer for the Sloan School's one-year program.

Dick Schmalensee writes that he is still in San Diego teaching economics and trying to do research. . . . **Dick Schwarz** was married to the former Lee Ann Chappelear on May 20, 1972. The Schwarz's are now living in Springfield Township (an Akron, Ohio suburb) and trying to make a house into a home. . . . **Ezra Armstrong** is the new manager of marketing research for the J. M. Smucker Co. (jams and jellies) of Orrville, Ohio. He has previously worked for Kellogg Co., Chrysler, and Proctor and Gamble.

John Howard received his Ph.D. in Computer Science from the University of Texas in December, 1970 and is now an Assistant Professor of Computer Science there. The Howards have two sons, Gregory and Alexander. . . . **John Holdren** has been on leave from the fusion program at Lawrence Livermore Laboratory since January 1972, serving as Senior Research Fellow in the CalTech Population Program and the CalTech Environmental Quality Laboratory. John is coauthor of *Ecology: Problems and Solutions* published by Freeman and Co., last March. . . . **Scott Graham** is a member of the

scientific staff of R.C.A. Laboratories at the David Sarnoff Research Center in Princeton. Scott is a member of the Solid State Technology Center and holds a master's and Ph.D. in electrical engineering from Stanford. Scott and wife Freya live in Ringoes, N.J. . . . **Dave Curtis** is still with the Division of Naval Reactors of the A.E.C. and is involved with reactor design and production. The Curtis's have two boys, the second born last November. . . . **Craig Wheeler** was author of an article, "After the Supernova, What?" in *American Scientist* for January-February 1973. Craig received his Ph.D. in 1969 from Colorado and did postdoctoral work at CalTech. He is now an Assistant Professor of Astronomy at Harvard Observatory. And that is *two* months' notes. You folks are just not trying.—**Steve Lipner**, Secretary, 3703 Stearns Hill Rd., Waltham, Mass. 02154

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Shar and I were very happy that **Fred Goldman**, **Bob Howard**, and **Chuck Hottinger** were able to attend our wedding in April. Bob arrived two minutes before the ceremony, carrying two bottles of champagne that he had just won on his flight from Florida to San Francisco. The airline had a contest to see which passenger could "guess" the plane's location at a certain time, given plane speed, headwind, etc. Since the problem was deterministic, Bob reached deep into the bag of M.I.T. tools and found the right answer! And you all thought $1700 was too damn much.

Andy Mera has been living in Munich, Germany, the past two years. Andy recently changed jobs from Control Data to the European branch of a Los Angeles based firm named MacNeal-Schwendler Corp. He has been learning both German and Italian. . . . **Jim Triant** writes: "After graduation, I matriculated at the Columbia School of Dental and Oral Surgery, after which I spent a year in a rotating dental internship at the Brockton V.A. Hospital. Shortly thereafter, I married Diane Speare (Wellesley '68, Harvard '71), and about a month ago I opened my dental office for general practice at 164 Galen St., Watertown, Mass. Also, I have heard from a few of our classmates: **Bill Dix** is finishing his master's at Sloan this spring; **Joe LaBreche** recently became engaged to Betsy Gage (Simmons); and **Andy Skibo** is moving from here to Greensville, S.C."

Dave Mechler is looking this summer for job opportunities in Europe, primarily in Switzerland and Germany; Dave is still in electrical engineering at the University of Pennsylvania. . . . **Richard Stein** writes that he is finally employed after a year of scratching and interviewing. He is with the National Bureau of Standards, and his research work relates to his Ph.D. dissertation. . . . **Ed Kirsch** completed his internship at the University of California, San Francisco, and is now with the Kaiser-Permanente Health Plan in San Jose. . . . Carol and **Robert Landley** are building a house on five acres in the woods. . . . **Neal Gilman** is finishing his internship in southern California after graduating from the U.C.L.A. Medical School. . . . Catherine and **Bill Caton** have a daughter, Jennifer, born October 25, 1971. Bill finished medical school at the University of Southern California in June, 1971, and interned at the Los Angeles County Hospital-U.S.C. Medical Center. He is currently a resident in neurosurgery.

Roy Gamse has graduated from Harvard Business School after a three-year hiatus with an occupational deferment at M.I.T.R.E. Corporation. Roy is now in Washington with the Environmental Protection Agency where he is working on the relationship between environmental and energy problems. . . . **Edie Goldenberg** will be joining the political science faculty at Stanford next year. Edie writes that during her last trip to M.I.T. she "found it much changed and mostly for the better. It seems much more alive, aware, and involved than it was in the 1963-67 period. Thank goodness!" . . . Anita and **Dick Schulze** are enjoying northern California. Dick is Assistant Staff Judge advocate at Travis A.F.B., California. . . . In 1972 **John Shufelt** left Cogitate, Inc., a computer service firm which he founded six years ago. John is now President of Premium Marketing Headquarters, Inc., a Birmingham, Mich., company that designs and runs incentive and motivation programs for companies on a national basis. . . . In June, 1972, **Michael Cohen** became Director of Data Processing for Maker Terminals, Inc., the second largest cargo terminal operator in the Port of New York. He previously worked for Digital Equipment Corporation.—**Jim Swanson**, Secretary, 11567 Circle Way, Dublin, Calif. 94566

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I recently returned from a business trip from San Francisco which makes the third trip there in six months. While there I spoke to **Roy Shapiro**, who is working for a doctorate in the Stanford Operations Research Department. While there I also saw Howard Charney '69, my former neighbor in Eastgate, who has been working for I.B.M. in San Jose but is now planning a change in professional goals. Back in Washington we met with **Bill Ryder** who is working here for the Defense Department and who recently bought a quarter of a 4-plex house in the new city of Columbia, Md. **Rick Lufkin** recently dropped in with his bride, Ruth. Rick got out of the navy in November and then flew to Australia to marry Ruth, whom he had met while he was studying at the Wharton School. After a honeymoon spent sightseeing downunder, they moved to Corning, N.Y. where he works for a well known glassworks. They came here to go furniture shopping.

Finally, the case of the mystery rat has been solved. As you may remember, a '68 rat was found with the initials "G.P.A." on it, or so it appeared. However, there is no one in our Class with those initials. It turns out that it belongs to **Gary S. Anderson**—the script engraving can be ambiguous—who is now working with the Sea Pines Co., as a real estate developer in Hilton Head Island, S.C.

Milestones

On August 16, 1972 **Jerry Sabath** was married to the former Cathy Helstein. Cathy is teaching third grade in Burlington Memorial School, while Jerry is still trying to improve air traffic control at the Department of Transportation. . . . Kathie and **Ron Bohm** are living in Miami and loving it. They asked us to mention that their son, Matthew Brian, celebrated his first birthday on May 31, 1973.

Selective Service Stories

John Niles writes that he visited Sicily, Turkey, and Spain during the fall, courtesy of Navy Patrol Squadron 26. He is now back at N.A.S. Brunswick, Maine. . . . At Ft. Harrisson, Ind., **Ken Wong** is teaching in the Department of Data Processing of the Army Adjutant General School. He will be getting out in August and will be in a Ph.D. program in computer science at Washington University in St. Louis. . . . **John McFarren** is stationed at Cannon A.F.B., New Mexico as a weapons systems officer in the F-111D. . . . Finally, **John Baravecchio** writes that he was "kicked out" of the army in February. After "bumming around" for a while, he returned to grad school in the Molecular Biology Department at Berkeley.

Still Studying

Also at Berkeley is **Scott Davis** who is in a Ph.D. Program in mathematical psychology. He enjoys being a T.A. and R.A. and has received a 1-H deferment, if that matters any more. . . . After spending three years in Texas working for Bell Helicopter, **Roy Benveniste** returned to Boston and Harvard Business School. He plans to finish in June 1973 and then work overseas for a few years. . . . In a somewhat similar situation is **Eric Schuetz.** He spent three years with G.E. in manufacturing management and is now halfway through H.B.S. He will be working for Boston Safe Deposit and Trust Co., this summer and writes, "It will be good to get back in a working environment for three months after all those cases. . . . On the other side of the ocean, England, **Bob Bengen** expects to receive an M.B.A. in business administration in June 1973. . . . **Jorge Romero** is finishing an internship at University of Chicago Billings Hospital. He will then be at N.I.M.H., Bethesda for two years. He writes they have a new arrival: Sofia Teresa, age 8 months. . . . Down south, **Paul Gluck** is finishing his internship and is staying at the University of Miami Affiliated Hospitals to do his residency in OB-GYN. His wife Joan will be a pediatric resident there. They write that the few moments they have off together are spent really enjoying the life in Miami. "Sailing on Biscayne Bay is a far cry from Tech Dinghies in the Charles River Basin. Unbelievers are welcome to come down and see for themselves."

Working in the World

From Chicago, **Curtis Blaine** writes that he is Manager of Performance Data in the Medicare Division of the Blue Cross Association. He has become a devotee of

Zen Buddhism and intends to become a member of the Chicago Zen Buddhist Temple. . . . **James Marshall** has been promoted to Production Manager at Colonial Abrasives Co., near Philadelphia. . . . Out west, **Gene Stark** has joined the staff of the Laser Research and Technology Division at Los Alamos Scientific Laboratory. He and his wife, Gail, have two sons, Kevin and Jeremy. . . . **Russ Silverman**, his wife, Debbie, and their son, Aaron, are living in Miami now, where Russ is a licensed Nursing Home Administrator. They welcome anyone visiting the area to call and say hello. . . . Finally we received a letter about the exploits of **Duncan Teague** from an unbiased source, his wife Judy (other spouses are invited to do likewise). They are living in Memphis and he was recently named "1973 Outstanding Young Educator of Memphis and Shelby County." He earned an M.A. in Elementary Education from Memphis State University through the National Teacher Corps (designed to teach the disadvantaged child). He has been head of the science department at Geeter High School, and a physics and physical science teacher, for three years. This year he is piloting a new science course in the city schools. He is also president-elect of the Memphis Science Teachers Association. On the home front, Judy and Duncan have two girls, Kathy, 3, Christy, 1.

That's all for this month. Hope you're having a good summer—drop us a line about how things are going.—**Gail** and **Mike Marcus**, Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

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The mailbag is rapidly dying of starvation. This month's column will be a quickie. **Don Edwards** writes that he is in his third year studying neurobiology in the Biology Department of Yale's graduate school. He hopes to get his Ph.D. in June of 1974; following that, his plans are not clear. In September of 1971, Don married Genevieve Steele, Wellesley '71—"another proof of the virtues of the exchange program." . . . **James C. Seaton** is "working happily." He will be taking a 7-week cross-country jaunt this summer—if gas is still available—with his wife, Eleanor (Mt. Holyoke '70). . . . Since he graduated from M.I.T. in June of '71, **Roderick S. Walker** has been working in Arlington, Va., for American Management Systems, a three-year-old computer and financial consulting firm. . . . **Marc S. Weinberg** "dreams about finishing" a Ph.D. in Mechanical Engineering in September. . . . **Jeffrey R. Kurland** was recently appointed a consultant to the international staff of the White House Office of Telecommunications Policy in Washington, D.C. . . . **George C. Allen, Jr.**, informs us that **Ernie Nall** will be marrying Judy Williams, thus making Ernie a brother-in-law to **Sandy Harlow**. . . . **Peter Marmorek** writes that after a year of "working/playing/teaching" in London, England, and a year of "getting paid too well for too little" for the Ontario Government, he decided it was time to become a *real* teacher. He is just about to get a B.Ed. from Queen's University ("which is to M.I.T. as job training is to education"), which will qualify him to spread the gospel in English, Math., and Guidance. Peter is still single, and happy.

Sue H. Emerick is student representative for the Anti-Smoking Project of Howard University College of Medicine. Sue is presently on her gynecology rotation at Freedmen's Hospital, with obstetrics next. . . . **Lim Ming Chui**, one of the top ten table tennis players in the U.S., recently played in the first Providence Open, sponsored by the Rhode Island Table Tennis Association. At the age of 15, he was the number one player in Hong Kong, and last year he was selected for the U.S. team which played the touring Chinese team in several locations throughout the country. Lim is currently working for a computer firm in Billerica, Mass. . . . The Army Home Town News Center in Kansas City, Mo., informs us that Army Specialist Five **Thomas O. Bales, Jr.**, was recently awarded a certificate of achievement while serving with the 3rd Infantry Division in Schweinfurt, Germany. He earned the award for meritorious service as a fire direction center computer programmer in Battery A, 2nd Battalion, 39th Field Artillery of the Division's 1st Brigade. Spec. Bales entered the army in January 1971, completed basic training at Ft. Polk, La., and was last stationed at Ft. Sill, Okla. Before entering the army he was a teacher at Pensacola (Florida) Academy of Arts and Sciences.

Your Secretary recently returned from a vacation in Israel, plus a couple of days in London, and was fortunate enough to be in Jerusalem for the Independence Day Parade on May 7. It took a great deal of effort to convince myself to return to the States, and I'm eagerly anticipating my next visit. That's all for now. Happy summer!—**Laura Malin**, 406 Beacon St., Apt. 1, Boston, Mass. 02115; **Robert Vegeler**, 800 N. Smith Rd., Apt. 7-W, Bloomington, Ind. 47401

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An M.I.T. graduating Class these days seems to complete its work more as a slow dribble than as a crashing wave breaking in June. Hence, as another school year ends, congratulations are due, not only to those of you who picked up various esoteric advanced degrees, but also to those who, like your servant, never quite made it last June, but by now have finally graduated. Anyway, I hope to hear from those of you who are about to embark upon new adventures, as well as those who are presumably settled down and have plenty of leisure time to write.

This month brings a number of short items. **Dave Burns** is working in the Draper Labs. . . . **Ric DiCapua** is working for Leviton Electronics in New York and hopes to start Harvard Business School in the fall. . . . **Steve Chessin** took a year off to work for I.B.M. and will be entering Berkeley in the fall to start a Ph.D. program in experimental elementary particle physics. . . . **Pete White**, formerly our president, is married, living in Charlestown, and back at the Institute looking for a degree in computer science. . . . **Ernie Brogmus** is returning to M.I.T. to the Sloan School this fall. . . . **Paulette Kantor** has been working in the National Center for Scientific Research Laboratories of France, just outside Paris. She, too, will return for graduate work in the fall.

Alfredo Sadun writes from the Albert Einstein Medical School, "My heart's still in Cambridge. I still root for the Bruins and Celtics and I still think of myself as an M.I.T., student. Medicine can be boring but fortunately I've just started on a new, exciting, big research project which should keep my spirits up."

Finally, this laconic report came my way: Joe Clift qualified for the Boston Marathon. No word yet on the results.—**Dick Fletcher**, Secretary, 135 West St., Braintree, Mass. 02184

Conversation Pieces

Technically intriguing items from TRW, guaranteed to add luster to your conversation and amaze your friends.

Is anyone out there? The question of whether life is unique to planet earth has long fascinated the mind of man. As early as the 4th Century B.C., the Epicurean philosopher Metrodoros said, "To consider the earth as the only populated world in infinite space is as absurd as to assert that in an entire field of grain sown with millet, only one grain will grow." In the sixteenth century the heretic Giordano Bruno announced that "innumerable suns exist" and "innumerable earths revolve about these suns . . . Living beings inhabit these worlds."

Harvard astronomer Harlow Shapley approached the problem statistically. Of the 10^{23} stars in the universe, said Shapley, it is probable that 100 million have planets similar enough in composition and environment to earth to support life.

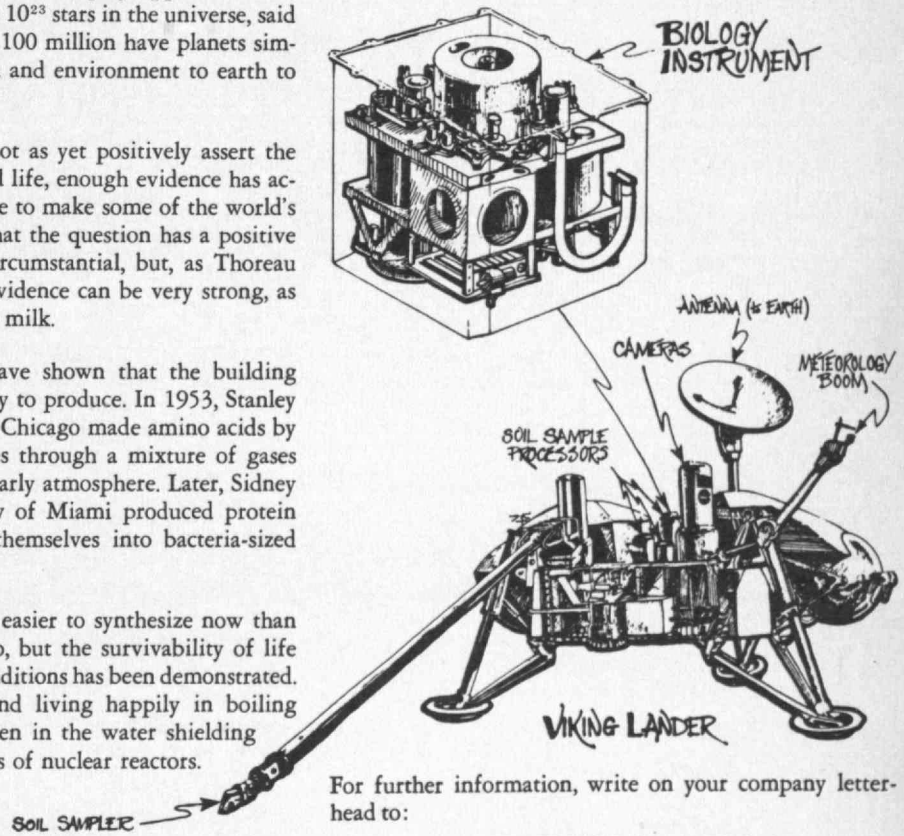
Although scientists cannot as yet positively assert the existence of extra-terrestrial life, enough evidence has accumulated in the last decade to make some of the world's leading scientists suspect that the question has a positive answer. The evidence is circumstantial, but, as Thoreau said, some circumstantial evidence can be very strong, as when you find a trout in the milk.

First of all, scientists have shown that the building blocks of life are rather easy to produce. In 1953, Stanley Miller of the University of Chicago made amino acids by passing electrical discharges through a mixture of gases that simulated our earth's early atmosphere. Later, Sidney Fox of Florida's University of Miami produced protein fragments which formed themselves into bacteria-sized spheres.

Not only does life seem easier to synthesize now than it did twenty-five years ago, but the survivability of life under presumably lethal conditions has been demonstrated. Organisms have been found living happily in boiling water, strong acids, and even in the water shielding the highly radioactive cores of nuclear reactors.

Recently, biologists have simulated the biologically rigorous conditions of the Martian environment in "Mars jars." Some of the organisms placed in the jars readily adapted themselves to the extremely cold carbon dioxide atmosphere.

As a subcontractor to Martin-Marietta, TRW Systems is at work on a NASA project which may shed some light on the question of extraterrestrial life. We are building the Viking Lander Biology Instrument, three tiny, fully automated laboratories, which will be landed on the Martian surface in 1976. On earth, these laboratories would occupy several rooms and a full crew of scientists. We are shrinking them into a single foot of space. We hope you're interested as we are in what Viking will find.



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